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Walter C. Boynton,
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Supplement to
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For the greater convenience of the reader this index has been made both titular and topical in nature. Original titles of articles have been amplified or condensed for the purposes of the index as seemed best. Subjects have been indexed which are treated in articles and not originally embraced in the title. Nothing has been indexed under "concrete" and nothing under "cement" except when the nature or testing of cement is involved or some statistics as to its production or use. In short, "cement" has been used as an index word only when it appeared as the only comprehensive way of designating the matter. Illustrated articles are denoted by an asterisk after the title. Editorials are designated by "E"; articles in the Information and Consultation department by "I-C"; Correspondence department matter by "C" and New Equipment Methods and Materials department articles by "Eq." The months and pages are given.

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Concrete

Cement Age

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The Farm Contractor's Opportunity

THE silo is recognized by most farmers as a necessity and those few not so recognizing it are under the educational pressure of farm papers, the grange, and the experiment stations—not to mention the commercial advocates who have silos to sell.

By similar educational processes the farmer is either already convinced or is in the way of conviction not only that the silo is a necessity, but that the concrete silo is an economy.

The concrete silo does not decay, it is not destroyed by fire nor is it blown away by high winds. It is well established that it is not attacked by the acids of ensilage—no more than good, dense, concrete pipe are attacked by any ordinarily severe test in sewage or in alkali soil. The natural skepticism aroused by the suggestion of the use of a new material is disappearing in the face of demonstrated value and by the increasing years of use which put that value to its real test. Objections to concrete silos are disappearing. The demand for them is increasing. The types of this construction are numerous and it merely remains for many small town contractors to develop this line of work for farmers, as scores have already done with marked success.

The Farm Contractor's Responsibility

THE real promise in the farm contractor's opportunity lies in the seriousness of his recognition of the responsibilities which go with it. Good silo jobs mean many more silo jobs; a few poor jobs are likely to ruin the concrete silo development of an entire community. One silo contractor writes that he is keeping seven construction gangs busy. Obviously this man has done something in an educational way to make the farmers see the economy and worth of what he has to offer, and probably not the least important thing he is doing to make the farmers of his locality see these advantages, is to see that each one of his seven gangs knows what it is doing and that each gang leaves behind it a good advertisement for more business. Farm contracting, particularly in such lines as silo construction, is not to be gone into without the mechanical equipment and the skill necessary to *make good.* The warning is already sounded against bad workmanship. The experiment stations, while unanimous in their recommendation of the concrete silo, are insisting upon the importance of having competent builders do the work. For instance, a letter from the Michigan Agricultural College contains these paragraphs:

> From the information at hand, the concrete silo seems to be generally used through the southern part of the state where, when properly built, it is giving excellent satisfaction.
>
> So far as we can determine, the main deterrent to its use in other sections of the state, is the difficulty in finding competent builders. We have at the college offered to assist farmers in groups of three or four who wish to erect concrete silos, by furnishing information and offering instructions as to methods of building. We have not endeavored to send out forms for the use of farmers, as has been practiced by some institutions.

The silo contractor will have no difficulty in equipping himself with convincing selling talk for use in getting the farm business. Plenty of authorities who have the farmer's welfare at heart, have considered carefully and endorsed enthusiastically the thing which the concrete silo contractor has to sell. Such information is to be had for the asking, from the U. S. Dept. of Agriculture, numerous state experiment stations, and from cement companies. The silo contractor has merely to appropriate and capitalize this information and then go about doing the kind of work which is more convincing with the farmers than the government bulletins—good concrete work, that stands as its own best recommendation.

The Development of the Concrete Road

THE present tendencies in concrete road construction are of unusual interest. The half dozen years in which the work has had very active development have at last afforded time in which to give intelligent study to the results. Errors have had time to become apparent and weaknesses to be recognized and analyzed.

All along the expansion or contraction joint or what may perhaps more properly be called the movement joint, has presented the major problem. Now we find in 1915 work that the joints are being spaced much farther apart in the road; that there is a tendency to eliminate metal protection devices, and that in still other work the prepared joint is being done away with altogether except to mark interruptions in the progress of the concreting.

Far more attention is being given to the selection of the materials. The aggregate is more strictly and definitely specified and the thoroughness of mixing and the consistency of the mixture are being given somewhere near the attention which investigations have shown these features deserve.

Very few problems of the nature of concrete road construction have been grappled with more determined or more general effort. The concrete road came when it was needed—when the automobile was tearing other roads to pieces. It came at a time when a low cost road with good promise of permanence was imperative. It came, however, with flaws, due to the fact that it was not thoroughly understood. Its rapidly increased adoption is a tribute to the many individuals and institutions applying zeal and ability to the matter of its proper development. Much of this study was applied as a result of commercial interest—the sale of the essential ingredient, Portland cement. Yet even in this there can be no stinting of praise. The study has been no less thorough; the results not less, but more satisfactory. Haphazard methods have been analyzed for their weaknesses and practice is as well on the way to complete standardization as could possibly be expected in so short a time, in view of the local considerations of available materials, costs and other varying conditions.

Roads are still being built of which only a short period of usefulness can be expected. Such work, however, cannot do the great damage to the development of the type which bad work did in previous years. Now there are hundreds of miles of work which can be counted upon to justify itself in the eyes of taxpayers. When a bad concrete road is seen nowadays, everybody knows it is a *bad* concrete road. It is not typical—it contained poor materials, or is the product of poor workmanship.

There is a great difference between early specifications and the 1915 specifications. The present standard specifications will undoubtedly be still further improved. It is inconceivable that "the last word" could have been said in the time in which public attention has been directed to the development of a type of road construction which is entirely new in so many of its features. There is just enough variance in the 1915 practice of the engineers who are directing the construction of big mileage of concrete, to indicate the lines of study for future work. As evidence of this the letters of several well known successful roadbuilders are quoted elsewhere in this issue.

The Autoclave Test

THE autoclave test for soundness of cement appears now to have been laid at rest. The investigation by the U. S. Bureau of Standards does not encourage its use and Committee C-1 of the Am. Soc. for Test. Mat. opines that it (the autoclave test) "should not for the present be adopted, for the reason that investigations which have been made of this method do not show that it is in any way superior to the present test for soundness."

The wood shingle has no equal as an agent in starting and spreading fire. Municipalities are beginning to realize this fact and to prohibit its use. In many sections at the present cost of singles and labor the saving over incombustible roofings is so little as to make the wood shingle of doubtful economy.

European countries are leading us in the use of concrete roofing tile, very likely because the shingle is unknown abroad and would not be tolerated by European ideals of safety and permanence.

There is one man to look out for. There is no proprietor or superintendent who can afford to have Mr. Happy Hazzard—familiarly known as Hap. Hazzard—working for him.

On every hand are evidences of more serious attention to the matter of the quality of the sand, gravel and crushed stone which are to be used in concrete.

On the business card of W. J. Eastman, Buchanan, Mich., silo contractor, appears the following: "Can your corn in concrete that your corn field may coin more cash."

Columbus, Ga., has gone on record. It bars the wood shingle.

Another Fire Test of Concrete

The Blue Grass Inn, near Newport, Ky., was partly destroyed by fire, the surviving portion of the building being concrete and steel, forming the floor of a dining-room and dance hall on the second floor. The incident is another conspicuous example of the fire-resisting properties of concrete. The Cincinnati *Commercial Tribune* printed a despatch in which it was said that, "notwithstanding the fact that tons of twisted steel, rock and brick covered the floor above, a dinner party was held in the grillroom last night." The owner of the hotel, Thomas N. Fordyce, stated that the total destruction of the building was prevented by the fact that the floor referred to was constructed of reinforced concrete.

A contractor recently won a law suit which was instituted to prevent him from operating a traction engine with trailer over a wagon road. The public as well as contractors are to be congratulated on the outcome of this case, as an adverse decision would have established a precedent by which any person who felt aggrieved by the use of this class of equipment over local roads could show that wagon roads are unsuited to such use. In road construction alone this haulage method effects a reduction of 10 cts. to 15 cts. per ton mi. and goes a long way toward paying the difference in cost between a temporary road and a relatively permanent road which would not be broken to pieces by tractors.

Many manufacturers of concrete building units — block, dimension stone, brick, etc.—will do well to rid themselves of the idea that their materials are not specified for good work because of prejudice. Sound, *good-looking* units are in demand. Be prepared to let the man who uses the material decide as to whether or not it is good looking.

To advocate the use of a material and then do a half-way job of manufacture or construction is an exhibition of the poorest kind of poor business sense.

Mr. Happy Hazzard still recommends measuring his materials with a scoop.

Building Concrete Silos—Unit Construction with Blocks and Staves

By C. D. Gilbert

Confronted by a failing supply of timber and by object lessons in the wastefulness and extravagance of temporary construction which yields to fire, tornado and decay, the farmer has become an extensive user of concrete. There are many odd jobs of concrete work which he has learned to do for himself and these smaller "experiments" with the material have taught him its value and ultimate economy. They have taught him to apply the same material in the solution of larger problems—the erection of more important structures, in which he has found it to his advantage to engage the services of men with the necessary experience and equipment. This is the field of the farm contractor. Silos represent at this time the most important line of work to be done for the farmer.

The concrete silo has had rapid and varied development. Its construction involves a choice among several types and it involves numerous interesting construction problems—a firm foundation; a rigid, tight wall to make the structure as nearly as possible like an enormous fruit jar; a chute; a roof; and in the construction, a scaffolding easily raised and lowered, a means for hoisting either the pre-cast units for the walls or the bucket of concrete in monolithic work.

In the preparation of two articles on silo construction, it has been Mr. Gilbert's purpose to consider briefly the special advantages of the various types of silo construction from the viewpoint of its development by individual contractors in different localities and under varying conditions; to consider the features of silo construction which are common to all silo work, and in this first article to consider unit silo construction with block or staves, summarizing the characteristics of various systems, and especially calling attention to the actual erection of the units, costs involved and conditions affecting successful silo building as a business proposition.

In a second article, for publication in Aug., 1915, Mr. Gilbert will take up corresponding phases of monolithic construction.

In each article it has been the author's purpose to bring together the best ideas in present-day construction practice, coupling with what are the successful methods already established some original ideas which should be of practical benefit to the builders.

There is no doubt about the superiority of the concrete silo when its construction is in the hands of competent and careful builders.

To the great number of small town and rural concrete contractors there is probably no single subject of more live interest than the concrete silo. The farmer realizes the necessity for a silo and in most sections has come to see the value of concrete as a permanent material. He has seen it go safely through fire, flood and hurricane and has learned that a concrete silo is insurance that he will have an unfailing supply of the best feed his farm can produce. The great reason why more concrete silos are not in the place of those built of less reliable materials is that in too many cases there was no builder available when needed, equipped to erect the concrete silo economically.

It is but a short time since silo building methods and equipment were brought to a standard of efficiency comparable to that of other construction. This, coupled with the fact that the average farmer was ignorant of the value of concrete and was familiar with other more widely advertised materials, made difficult the work of the pioneer concrete silo contractor.

Concrete silos are of two main types—unit and monolithic. Unit construction may be of block or of staves. Each type of silo has advantages which weigh more or less heavily according to local conditions.

The type of silo construction to be decided upon as a business will depend upon many conditions. Probably the greatest of these is the local sand and gravel supply; if these materials are plentiful and easily hauled to the site by the farmers throughout the territory in which the business will be done, factory-made block will not have an equal chance against the monolithic type, as shipping the block puts a heavy handicap on its manufacture. On the other hand, if concrete materials must be shipped or hauled from a distance, making them expensive, the factory product has an equal or better chance for business. This condition favors the concrete stave silo as it contains a much smaller amount of material than the block silo. Another advantage of the factory-built silo is that the units can be manufactured ahead of actual needs and anticipate the busy season. Probably 100 mi. is the extreme limit of operation from the plant and most of the work done must be done within a much smaller radius. Local preference has much to do with the situation, as a locality having set the seal of its approval on some one system makes sales of that type easier.

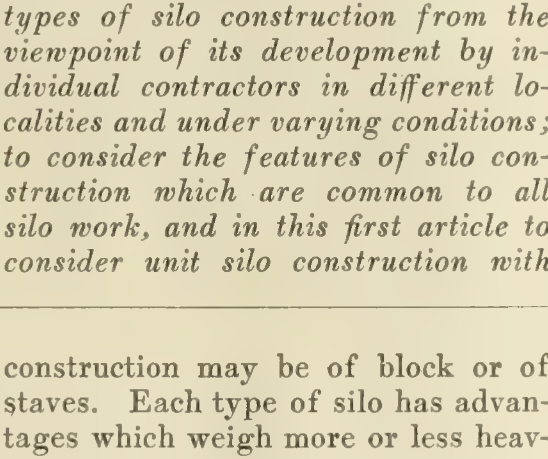

Fig. 1—Typical Silo Block

Note groove for reinforcing rod and concave ends for grouting

It is unnecessary to describe silo block making in detail. Many machines for this work will turn out good products in the hands of the careful manufacturer. A strong point in favor of the block silo in cold localities is that the hollow block—in proportion to the amount of hollow space—retards freezing and the two-piece block practically eliminates that trouble, though costing more. Figs. 1 and 2 show typical silo block.

FOUNDATION

The foundation is a feature to be considered. Often the farmer will prefer to put this in; if so, it can be deducted from the price for the complete silo. As to depth, 4′ 6″ is below frost and usually finds solid ground. It is easier to blow the silage a little higher when filling than to lift it out of a deep pit by main strength. A footing 2′ wide and 1′ thick is generally sufficient.

REINFORCING BLOCK SILOS

Given the footing properly in place and good block, well laid up, the one thing to secure a job that can be guaranteed without reserve is proper reinforcing. Every silo block should be cast with a suitable groove for holding the reinforcing rods, and this groove should be in the solid part of the block so as to be embedded perfectly in mortar when building. In double-wall construction the inner block should carry the rod, but in ordinary cored block it is probably better to put it outside the cores, (see Fig. 2). When necessary to spice rods they can be lapped for the length of one block, the ends turned down in the joint between the block the full depth of the block, (see *A*, Fig. 3). Table I gives data for reinforcing all sizes of block silos commonly used, and no less metal should be used.

The manufacturer should arrange to lay his own blocks wherever possible in order to be sure that the work is done in an efficient, businesslike and workmanlike manner. One or two carelessly put together jobs will go far toward discrediting a perfectly good product.

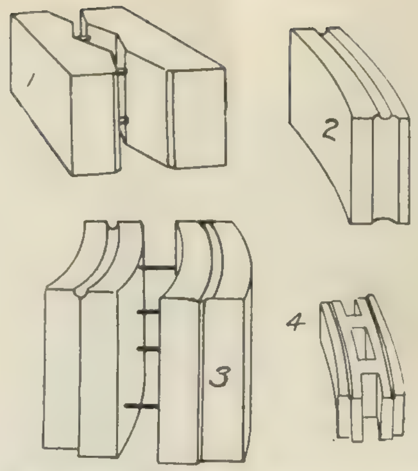

Fig. 2—Special Types of Silo Block

1—Anchor continuous space block[1]. 2—Kenny block[2], note concave ends for easy grouting. 3—Coyne block[3], cored and double, note interlocking ends

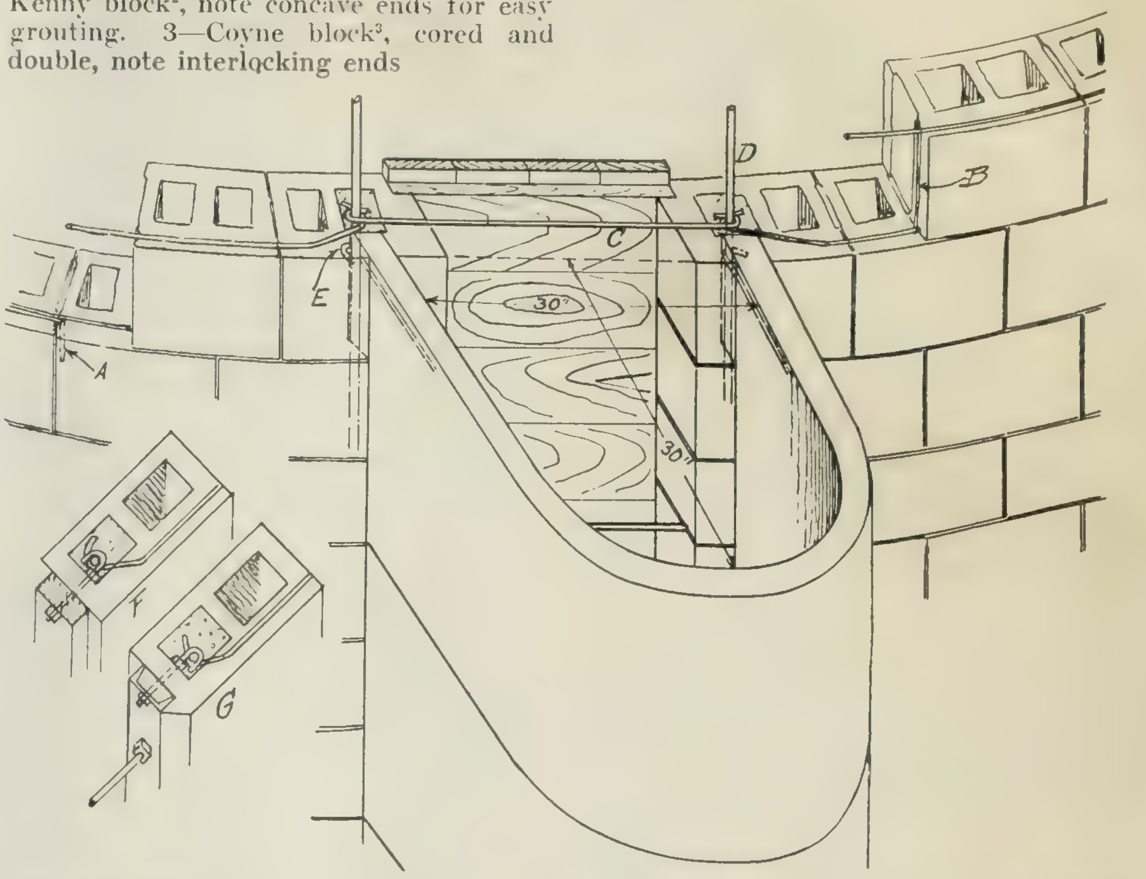

Fig. 3—Detail of Typical Block Silo with Reinforcing in Place, Also Doors and Chute

Note *A* method of splicing rods, *B* wire tie to hold rod in place while grouting, *C* ladder rod hooked to vertical rod, *D* vertical rod, *E* chute lug let into special block, reinforcing hooked to vertical rod and core grouted, *F* and *G* door frame details

To secure the reinforcing rods in the grooves so no difficulty will be found in placing the mortar, it is well to lay doubled wire under each rod at the middle of every third or fourth block. These wires will come in the joint of the next course and can be twisted over the next rod. Another way is to lay the wire under the block as laid (See *B*, Fig. 3).

DOORS AND FRAMES FOR BLOCK SILOS

Numerous inventors have devised ingenious and more or less satisfactory doors and frames. The continuous doorway is most in favor and justly so, because it allows the removal of silage at any desired height and is convenient and economical. Several door frames are illustrated in Fig. 3, but one which seems the most direct and least expensive method is shown in the larger detail. The block at the door are cast with a suitable jamb and a ⅞-in. hooked ladder rod is built into the wall, and encircles a vertical rod in the core of the block. The reinforcing rods are also hooked around the vertical rod and the core filled with rich concrete, binding all together.

Fig. 3 suggests the construction of a door much in use. This is simply two thicknesses of matched boards with roofing paper between them and arranged to overlap as shown. They are usually built in sections of about 2′ 6″. Matched or splined plank with a layer of paper roofing between wood and silage are tight and inexpensive doors.

Another common way is to use boards about 1′ x 10″, planed both sides, and place them across the opening in two layers, with roofing paper between and breaking joints. These are easily handled, require little labor to make and will not bind.

Do not make doors fit tight to

Table I

HORIZONTAL REINFORCEMENT FOR BLOCK SILOS

Showing size Wire and Rods to be used between alternate courses of block 8″ high

Feet from top of silo	DIAMETER OF SILO							
	8 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.	22 ft.
	Diameter of Rods in Inches							
0—4	No. 6	No. 6	No. 6	No. 6	No. 6	¼	¼	¼
4—8	No. 6	No. 6	No. 6	No. 6	No. 6	¼	¼	¼
8—12	No. 6	No. 6	¼	¼	¼	¼	¼	⅜
12—16	No. 6	¼	¼	¼	¼	⅜	⅜	⅜
16—20	No. 6	[illegible]	⅜	⅜	⅜	⅜	⅜	⅜
20—24	No. 6	[illegible]	[illegible]	⅜	⅜	⅜	⅜	⅜
24—28	¼	[illegible]	[illegible]	⅜	⅜	⅜	½	½
28—32	¼	[illegible]	[illegible]	⅜	⅜	½	½	½
32—36	¼	[illegible]	[illegible]	⅜	½	½	½	½
36—40	¼	[illegible]	[illegible]	½	½	½	½	½
40—44	¼	[illegible]	[illegible]	½	½	½	½	½
44—48	[illegible]	[illegible]	[illegible]	½	½	½	½	⅝
48—50	[illegible]	[illegible]	[illegible]	½	½	½	½	⅝

Courtesy Universal Portland Cement Co.

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[1] Anchor Concrete Stone Co., Rock Rapids, Ia.

[2] The Kenny Hoflund Co., Hawarden, Ia.

[3] J. J. Coyne, Fond du Lac, Wis.

sides of jamb, as they will swell so as to be almost impossible to remove.

ROOFS

Wood roofs are commonly used and factory-made roofs of metal are now a success. Some of the metal roofs can be opened so as to become temporarily a part of the silo wall, allowing more ensilage to be placed which, when settled, allows the roof to be closed, enabling the full capacity of the silo to be used. The metal roof is to be preferred to the wood roof and can be quickly placed and made to turn a profit to the contractor as agent.

It is a good plan to put eyebolts or staples on each side of the door, where a chute or not used, or under the dormer if the dormer is not over the door, and provide a couple of brackets like carpenter's staging brackets with hooks to engage the eyes in order to provide a staging at filling time; such a staging is a wonderful help in handling the blower pipe; these little things make friends and friends make business.

The concrete roof is fire- and wind-proof. While in some cases more expensive than the other types, it need not be so, particularly when the builders own proper equipment and have become accustomed to its use.

Cornice—If a concrete roof is to be used on a block silo, the simplest way to make a cornice is to build a special block for the last course. A special wood mold must be made for these block and they should be cast of a moderately wet mix to insure maximum density and strength. Fig. 4 shows such a block; the dimensions *A* and *B* should correspond to the regular block, and cores approximating the cores of the regular block should be used. The distance *C* is the desired projection for the cornice. The groove *D* should be as large as the space will allow and will hold a reinforcing rod and form a mechanical bond for the roof slab. The groove and top of the block can be swept to shape with a template.

A kink that will help in molding a well shaped cornice is a method of making molding to be used with circular forms. Usually only a little is wanted and can be made by screwing together thin strips of wood and working them to the desired outline and then taking out the screws and bending the molding as desired. As the moldings wanted are the reverse of stock shapes and the quantity wanted is small, they can generally be most economically worked out by hand. (See *E*, Fig. 4.)

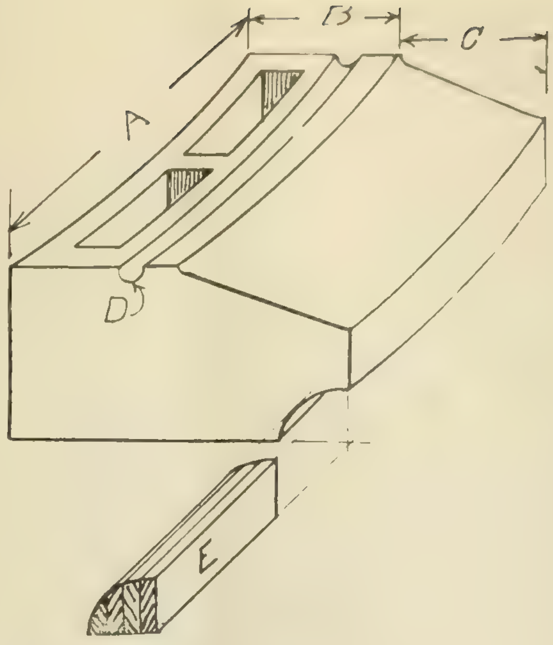

Fig. 4—Cornice Block

Note wash to cornice and method of making circle molding for form

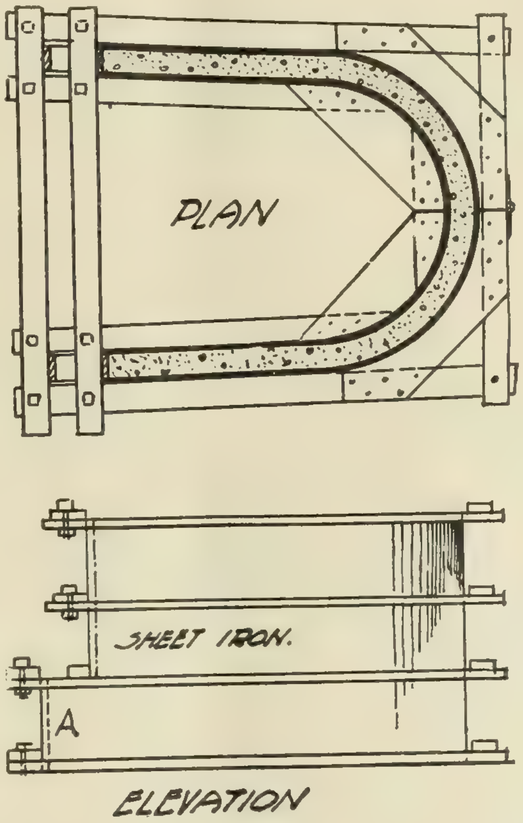

Fig. 5—Home-made Forms for Silo Chute

Note that a lug is cast at *A* which will interlock with wall and that chute units are cast bottom side up. See also Fig. 5

When laying up the block the cores should be stopped two courses below the cornice by pieces of metal or slate laid in the joint, or by a course of solid block. When the roof is poured the core holes are filled, bonding the three courses of block and the roof into a solid unit.

The method of building a concrete roof is determined by conditions. For one roof only very likely the most economical method would be to build a frame of rafters, butting against the silo wall, and supported by irons placed between the block for that purpose, the upper ends meeting on a tapered wood block arranged to be knocked out to loosen the forms. Light wood strips should be tacked to the rafters, bent so as to form a uniformly curved skeleton on which ribbed metal lath can be laid to receive the concrete. If this method is used, rings of light rods should be used in addition to the ribbed metal.

After the forms are removed this roof must be plastered 3/4″ thick inside to preserve and fireproof the metal. It may be more convenient to board the roof form and use rods for reinforcing, instead of metal fabric.

[Silo roof construction will be considered more in detail in a separate article to be published in Aug., 1915 —Editors]

CHUTE

The up-to-date farmer rightly insists on having a silo chute, as it protects the doorway from frost and makes it possible to remove the ensilage easily and comfortably in cold weather, without waste.

In many cases a feed room is built under the chute leading to the barn. This is a very desirable addition, as it keeps the passage to the stable always dry and warm. If the silo is close to the barn, as is usually the case, it adds little to the cost. With block silo construction the walls of the feed room would logically be laid of block and the roof be a simple flat or convex roof slab, properly reinforced.

So far as is known, no silo block manufacturer has used a pre-cast concrete chute, but in order to compete with other types and add to his income it behooves him to be prepared to furnish this detail.

In Fig. 3 is shown such a chute, in Fig. 5 the forms for casting it. One or two of these forms would probably turn out sections enough for most silo builders and they involve little cost. A unit of this size would weigh about 500 lbs. and should be handled easily by the scaffold derrick which lifts the block.

The first chute section should be set on top of the feed room roof slab. The chute sections can usually be cast in one piece and should be of a length determined by convenience, but equal, usually, to three courses of block. Enough block should be cast with an opening in the outside face to admit the chute lugs, and reinforcing allowed to project from the lug as shown, to be tied to the vertical reinforcing. The whole construction is thus bound together securely, and the weight of the chute distributed.

On very high silos it seems wise to leave openings in the chute at intervals of about 10′ to admit light, and also the blower tube, and save blowing all silage to the top.

SURFACE FINISH

In order to have a smooth surface for the chute the block at the sides of the doorway must be plain and

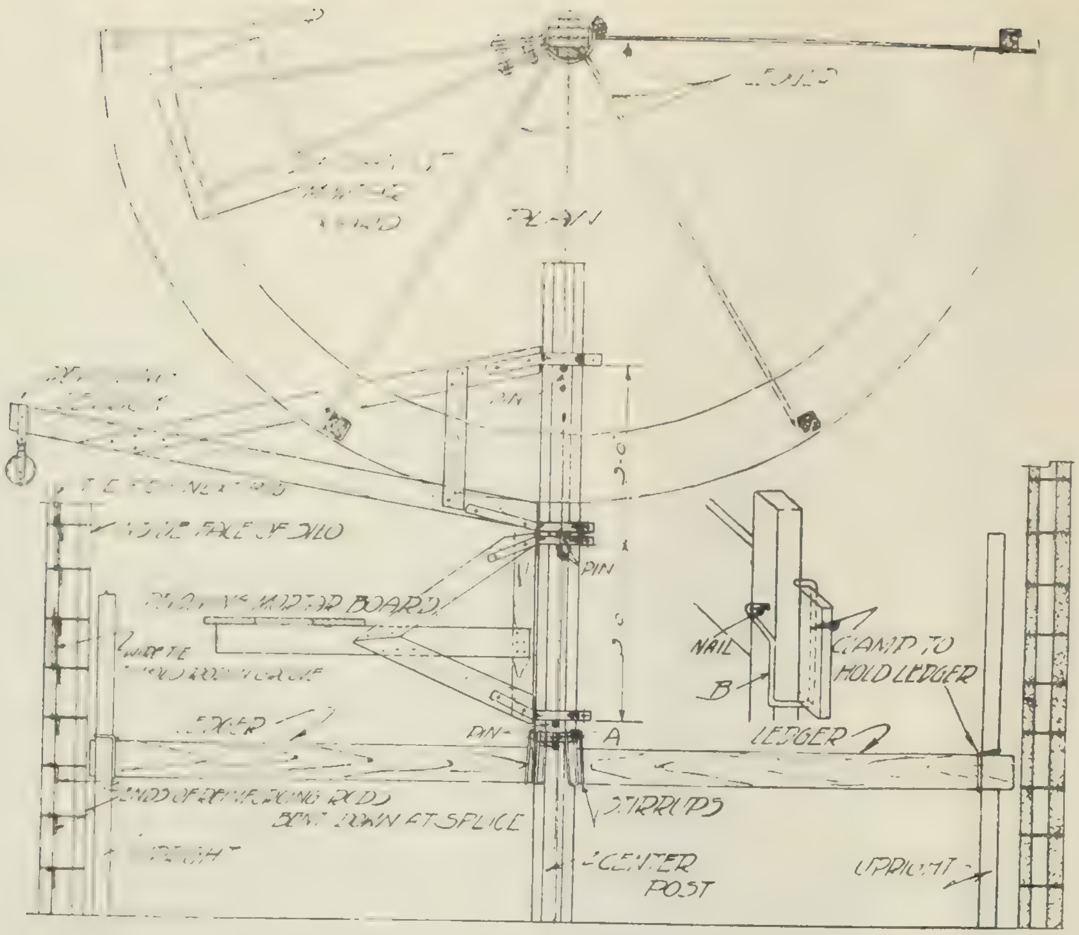

FIG. 6—DIAGRAM OF SCAFFOLD AND DERRICK FOR LAYING BLOCK AND TILE SILOS

smooth, in fact, the rock-face block should not be used for any part of the work. It requires more material and is less easily made waterproof because of a rough surface tending to hold water. It is generally an eyesore and has done more perhaps than any other one thing to hinder the advance of the concrete building unit. Make a good dense block, use a facing if the job will stand for the price, and let the job appear what it is—honest concrete.

Brushing the block while soft to expose the aggregate makes a desirable finish.

STAGING

Laying Block—In order to lay up a silo economically, proper staging should be provided. It will pay any one who has several of them to lay to build a special staging along the lines suggested at Fig. 6. The center mast can be made of 2-in. x 4-in. and 2-in. x 8-in. lumber which will make a roughly octagonal section. It should be arranged to break joints and the whole mast laid out upon the ground, bored for bolts and for pins as shown. A section can be set up and guyed in position perfectly plumb, other lengths to be added as needed.

The staging poles are 3″ x 4″ or 4″ x 4″, generally six in number, arranged and stayed to the mast. A stout iron ring, *A*, Fig. 6, supported by a pin carries ½-in. iron stirrups, which support the ledgers. At the outside poles a ledger clamp shown at *B* can be used to save nailing.

The mortar board shown in the drawing is a great convenience. It costs little to make and will save much time for the mason.

The derrick arm is equally simple and will place the block or staves along the wall ahead of the man setting the units, so he need not lose a minute. Fig. 6 is admittedly only suggestive and can be improved upon if one cares to go to a little more trouble. For instance, a casting to set over the pins for the mast irons to ride on would be easily made at any foundry and greatly aid in the smooth working of the rig. In raising it is easy to push up the derrick one lift of 3′ and insert a pin; the mortar board follows and is pinned where the derrick was before. The ledgers lift one at a time and hook to a second ring like *A*, the whole job taking only a few minutes. The use of a mortar gauge, the shape of the block and thickness of the joint, is often helpful. It enables just the correct amount to be spread.

SETTING THE UNITS

In some block and staves a bond is made by grooves on each end of the block. It is a tedious task to fill these with a trowel but if the mason merely "butters" the vertical edges of the block, a laborer can take a pail of thin grout and a tin funnel and fill joints quickly. A garden watering pot with the spray nozzle pulled off is even better.

SPECIAL FEATURES

The stave silo is a more recent development and has certain advantages. It is particularly adapted to localities where concrete materials are not generally available and where transportation plays a large part in their cost. The stave takes much less material and longer shipments can be made. The stave silo can be erected in a very short time, which is often a valuable feature.

Types of Staves—The principle of the stave silo is illustrated in Fig. 7, which shows some of the many types. All are based on interlocking units so arranged that exterior iron hoops bind them together securely. Some manufacturers curve the stave to the radius of the silo, while others use a flat stave which approximates any desired curve.

(Continued on p. 37)

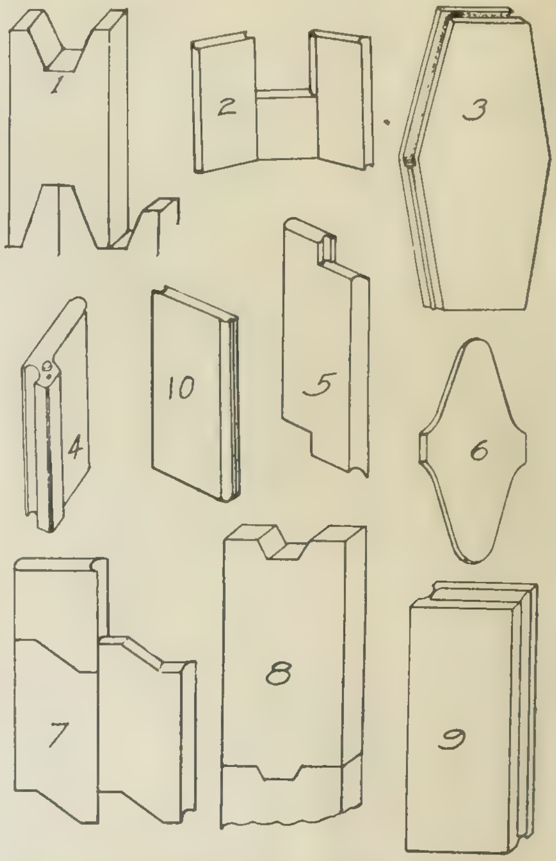

FIG. 7—TYPES OF CEMENT SILO STAVES

1—Secor[4]. Special lock top and bottom
2—Flat stave adjustable to any size silo[5]
3—Diamond[6]. Large interlocking surface and grout space
4—Playford[7]. Note large rib keeping hoops clear of wall
5—Success[8]. A reinforced stave interlocking with six others
6—Ellipse[9]. This stave gives an unusually even distributing joint
7—Interlocking[10]. The shape of this stave gives unusually evenly distributed pressure on the hoops
8—Swan[11]. A vertical joint interlocking stave
9—Battle Creek[12]. Vertical and horizontal tongue and groove are the features of this stave
10—Everlasting[13]. A V-shaped groove in the convex edge of this stave allows grouting

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[4] D. A. Secor, Cassopolis, Mich.

[5] Perfection Concrete Stave Silo Co. and Cement Stave Silo Co., both of Des Moines, Ia., have staves of this type

[6] Diamond Concrete Stave Silo Co., Kansas City, Mo.

[7] The Playford Mfg. Co., Elgin, Ill.

[8] The Success Silo System, Kansas City, Mo.

[9] Ellipse Concrete Stave Silo Co., Kansas City, Mo.

[10] Interlocking Cement Stave Silo Co., Des Moines, Ia.

[11] Swan Cement Stave Silo Co., Cassopolis, Mich.

[12] Battle Creek Silo Co., Battle Creek, Mich.

[13] W. W. Rohrer & Son, Orrville, Ohio

The New Deep Water Pier at Halifax, Nova Scotia

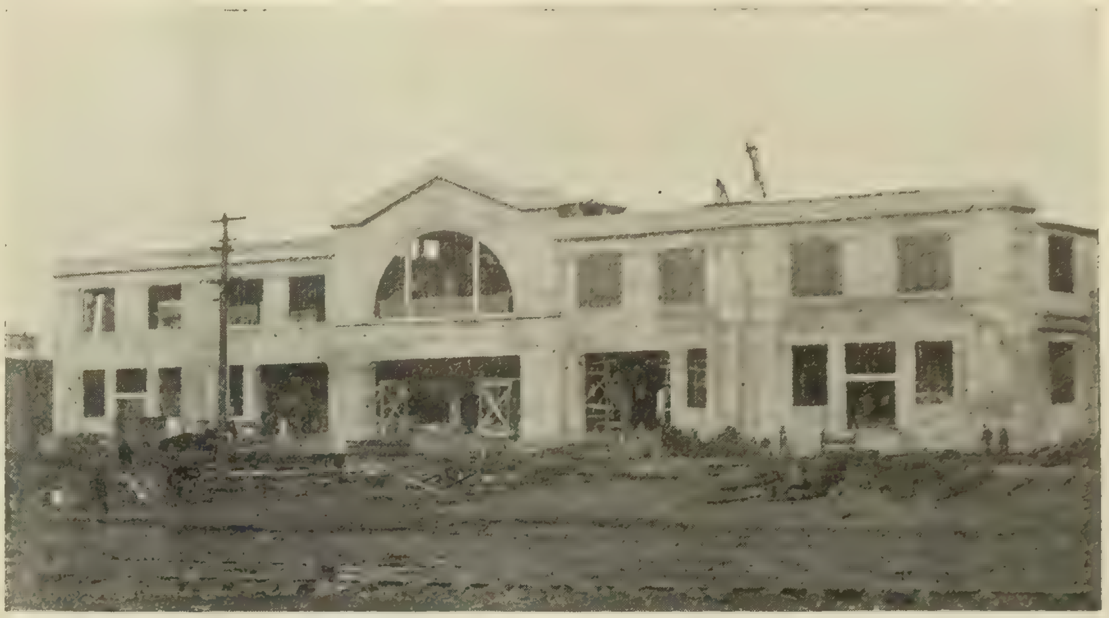
By A. F. Dyer[1]

This is the story of the building of an ocean steamship pier 235′ x 800′ on pre-cast concrete piles. As over 1,800 piles, 24″ x 24″, and from 45′ to 77′ long were used, it is evident that new and intensely interesting methods were developed. Not the least interesting feature is the enormous pile-driver, designed especially for this work.

Towards the end of 1910 the Dept. of Rys. & Canals of Canada decided to enlarge and improve the shipping terminals of the Intercolonial Ry., at Halifax, N. S., in order that the rapidly increasing transatlantic shipping making use of that port might be conveniently accommodated, and called upon John Kennedy, Cons. Engr. to the Montreal Harbor Commissioners to draw up the necessary plans of development.

The shipping piers then owned by the railway at its deep water terminals consisted of a flour-loading pier 470′ long by 50′ wide which had been built by Sir Samuel Cunard before he left Halifax to found the Cunard Shipping Co., Old Pier Two, 560′ long by 85′ wide, having a two-story wooden shed and used by incoming passenger and mail steamers, Pier No. 3, 610′ long by 165′ wide with a one-story freight shed used by incoming freight and outgoing passenger and freight steamers, and Piers 4 and 5 used for shipping coal and lumber. All these piers, being supported on timber piles and having wooden floors, required a considerable outlay for maintainance, for although the teredo is practically unknown in Halifax Harbor the limnoria is very active.

In the spring of 1911 the following scheme of development was put forward by Mr. Kennedy and approved of by the Dept. of Rys. & Canals: A new pier, 800′ long by 235′ wide, to be built on the old Cunard property in place of the Cunard pier, Old Pier No. 2 and the Immigration Building, all three of which were to be demolished, the last two on the completion of the new pier, which would then be known as Pier No. 2. Pier No. 3 was to be lengthened to 800′ and widened southwards to a width of 235′, leaving a dock 280′ wide between its



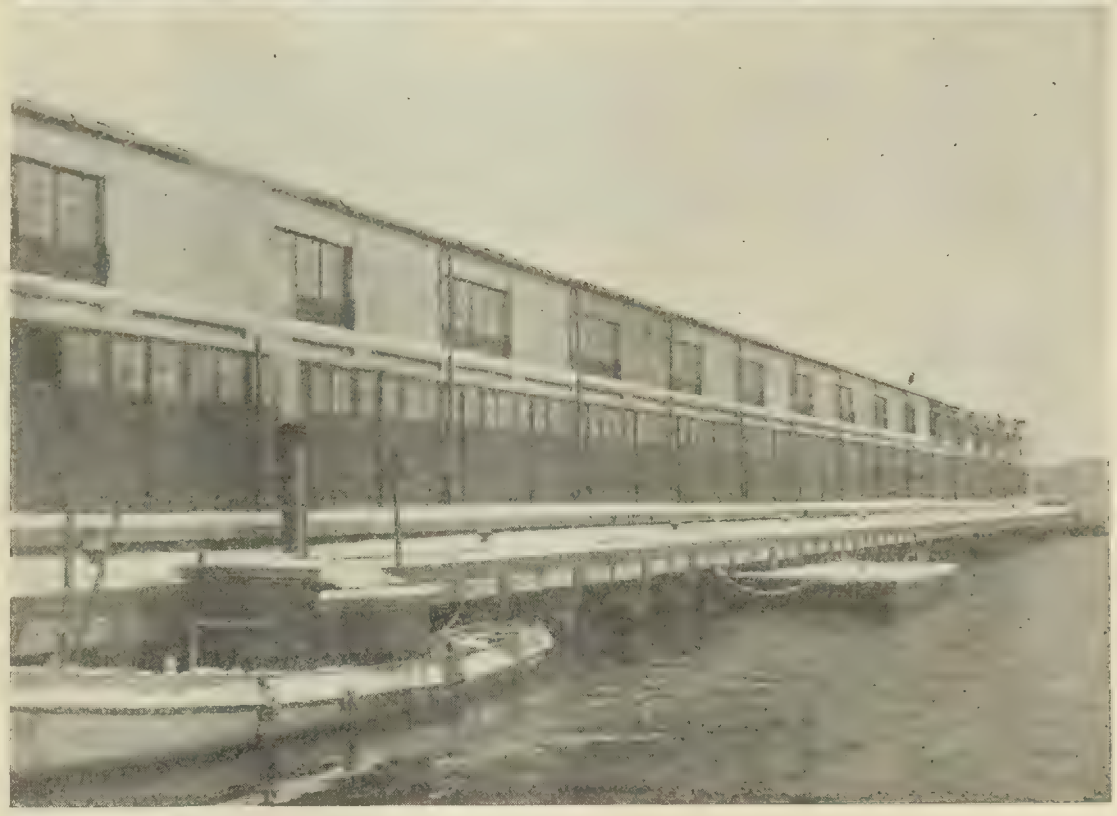


Fig. 1—Shore End of Pier

Fig. 2—Jan. 4, 1915, South Side of Pier Looking East, Work Practically Complete

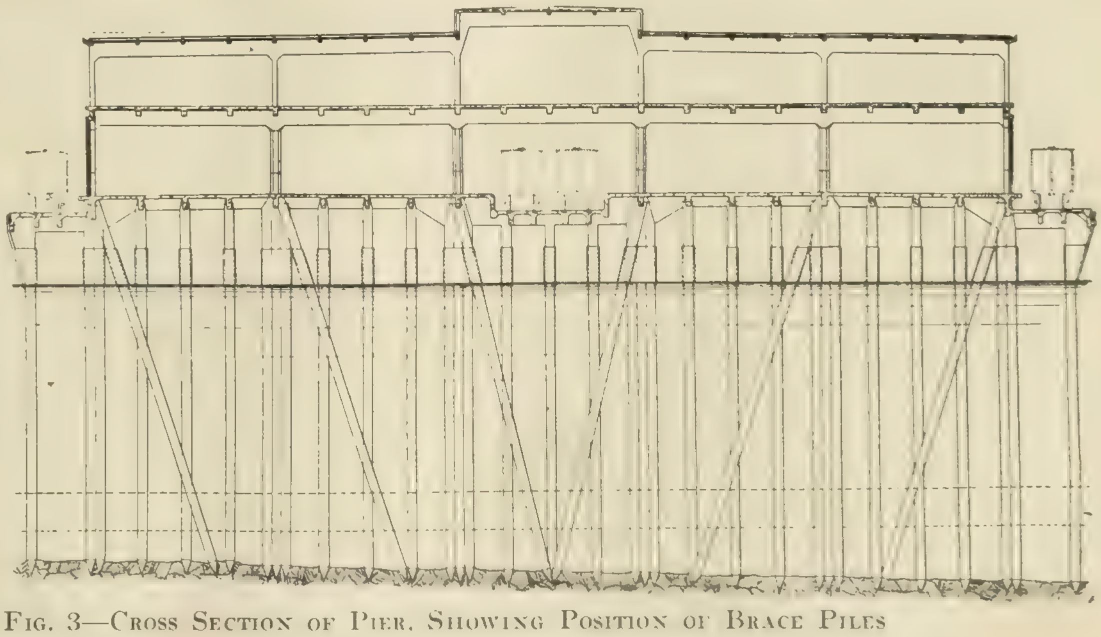


Fig. 3—Cross Section of Pier, Showing Position of Brace Piles
(Courtesy *Excavating Engineer*)

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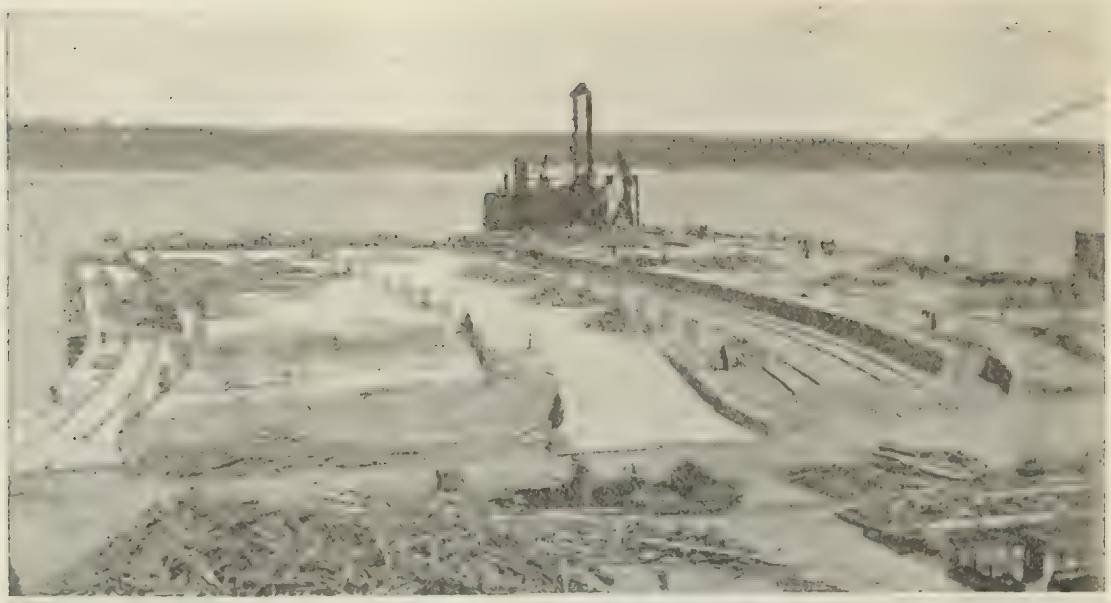
[1] Res. Engr. in Charge, Halifax, N. S.



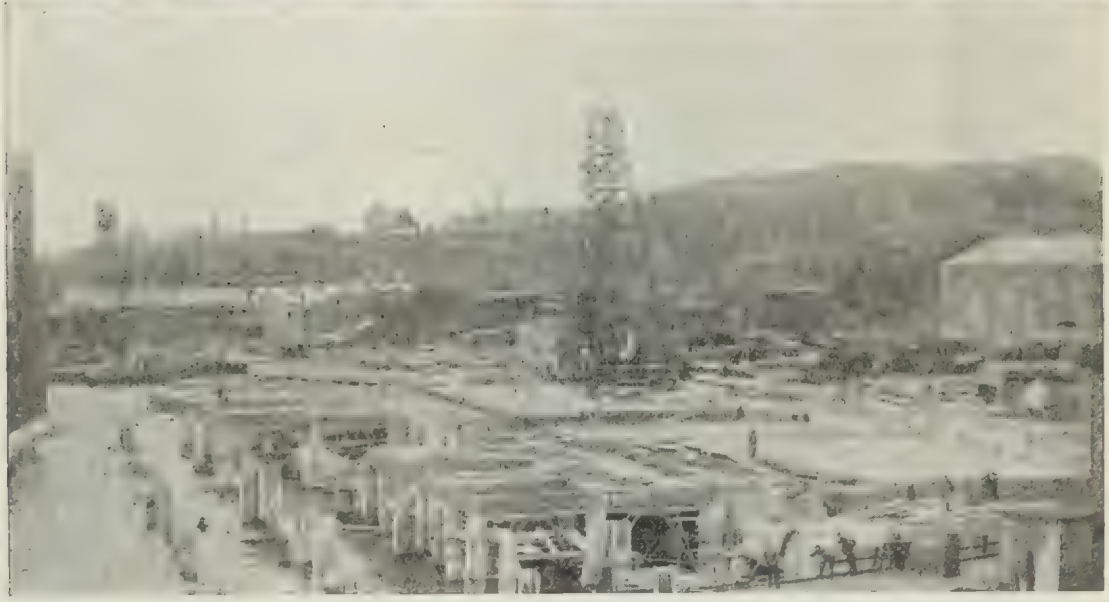


Fig. 4—This View Shows Pier Floor Under Construction with Pile-Driver at Work

Note raised shed floors and grooves in concrete floor for rails. Reinforcing rods projecting from floor are intended as bonding rods for shed columns

Fig. 5—Form Work for Pier Floors

Note forms for capping piles and brace piles

south side and the north side of new Pier Two. A new pier No. 4, 800′ by 235′ wide, to take the place of existing piers 4 and 5 with a basin 275′ wide on the north of Pier 3 and a fourth pier 700′ by 195′, 250′ north of Pier No. 4. This scheme provided for about 6,000 lin. ft. of berths for ocean-going steamers against the 3,320′ then existing.

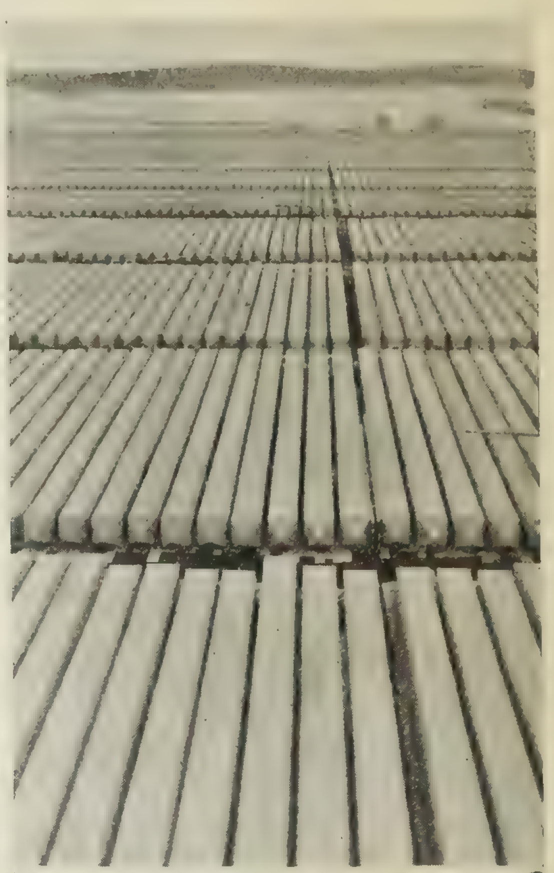
FEATURES OF DESIGN

It was decided to start work with building new Pier No. 2, as the construction of this pier would least interfere with the existing accommodation, the only pier to be put out of use being the small flour pier.

In designing the new piers the two considerations of economy of construction and permanence of the structure determined the type to be used, which is that of a reinforced concrete floor supported on reinforced concrete piles. This type of construction was well suited to the local conditions of the site where the depth of rock bottom varied from 42′ to 68′ below low-water level of spring tides which necessitated a substructure below the pier floor of from 61′ to 87′ in height.

Borings taken over the site of the new pier indicated that a layer of hard clay or hardpan covered the rock to a depth which varied from 2′ to 12′. Above the hardpan there was found a layer of soft mud which had a depth of nearly 30′ at the shore end but ran out to about 5′ at the outer end of the proposed pier.

The elevation of the pier deck was determined by the existing tracks in the railway yard and on the other piers at 19′ 2″ above extreme low-water level of spring tides which is 3′ 6″ above the top of the rail. Owing to the small height of the structure above low water compared with the depth of the foundations below low water, a system of diagonal transverse bracing would not have greatly increased the stability of the pier, and its ability to withstand the shock of a large vessel striking it on one of its sides, and therefore recourse was had to the use of reinforced concrete brace piles driven at an angle of 1 in 3 to the vertical and having their heads consolidated with the transverse girders of the pier floor. It is believed that this is the first instance of such a system of bracing being used for a reinforced concrete pile pier. Further stiffening of the structure was obtained by forming a bank of dredged material under the outer end of the pier, where the depth of water was greatest and the thickness of the material overlying the rock was least.



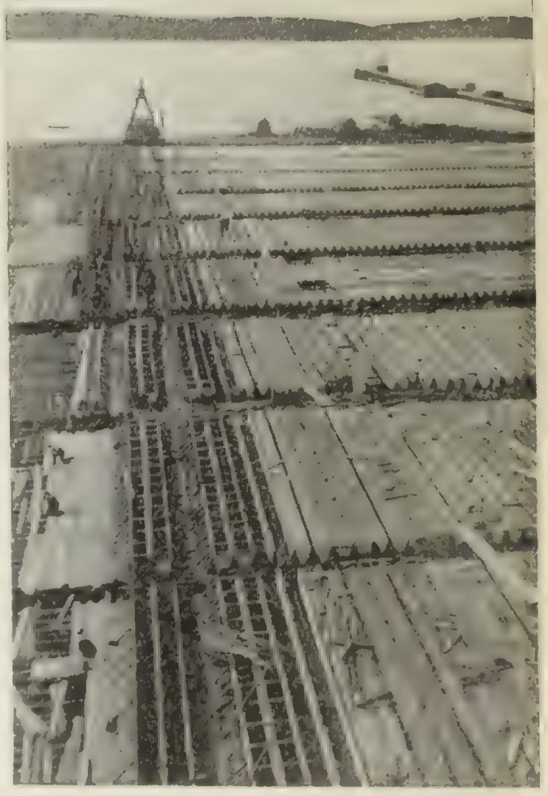


Fig. 6—View of Yard Containing 1,834 Piles

Each pile is 24″ x 24″ in section, lengths of piles range from 47′ to 77′. Note camber in piles to be driven as brace piles

Fig. 7—Casting Concrete Piles Near Halifax, N. S.

PROTECTING PILES FROM SEAWATER

The question of the durability of reinforced concrete piles immersed in sea water in a climate such as prevails during the winter months in Halifax had now to be dealt with. The large ratio between the surface exposed and the bulk of the concrete in this type of construction is one of its weak points and special measures had to be taken to prevent any deteriorating action of the water on the concrete.

The principal causes of deterioration of concrete immersed in sea water act between the levels of low and of high water and are: 1. The chemical action between the magnesium sulphate contained in sea water and the alumina in the Portland cement, which forms a sulpho-aluminate of lime within the concrete, thus disintegrating and weakening the structure. 2. The intermittent wetting and drying of the concrete with the rise and fall of the tide which causes an increase in the porosity of the concrete, ultimately allowing the water to reach the reinforcing steel within, which, on rusting, swells and bursts off portions of the concrete. 3. The freezing at low tide of the water absorbed by the outer surface of the concrete at high tide, with consequent scaling of the surface and exposure of fresh concrete surfaces. 4. The abrading action of floating ice on the concrete surfaces. Causes number 3 and 4 are the most active along the coasts of Nova Scotia, where the temperature frequently falls to 0° F., for at least three months in the year.

The measures taken to prevent, as far as possible, the above actions taking place on the concrete piles were: 1. The Portland cement used for making all concrete below high-water level did not contain more than 6.3% of alumina. 2. All concrete below high-water level was mixed in the proportions of 1 part cement, $1\frac{1}{2}$ parts sand and 3 parts crushed quartzite gravel, with the object of obtaining a rich concrete and one that would be rich and as dense and non-porous as possible. 3. All concrete surfaces from low-water level to about 2′ above high-water were sheathed with two layers of 2-in. creosoted pine planking, bedded in cement mortar. The inner surfaces of the planks were coated with pitch to prevent any deteriorating action from taking place between the creosote in the wood and the concrete of the piles. This sheathing keeps the concrete surfaces moist, prevents all frost action and protects the concrete from abrasion by ice as well as from the wearing action of the wash of the water.

The plans included the erection of a two-story freight shed 200′ wide and extending from the bulkhead line to within 15′ of the outer end of the pier. This shed allows room to run a railway track along each edge of the pier. Two additional railway tracks run the whole length of the shed down the center of the pier, dividing the lower floor into two separate freight floors each 88′ in width. The columns supporting the shed are spaced 39′ 6″ transversely and 18′ longitudinally, the long transverse span being decided upon in order to facilitate the handling of gangways.

The loads for which the pier and shed floors are designed are: Pier deck 1,000 lbs. per sq. ft. live load; track girders, 4,500 lbs. per running ft. of each rail live load; upper floor of shed, 500 lbs. per sq. ft. live load, and roof, 110 lbs. per sq. ft. total load.

DESIGN OF PILES

The longitudinal spacing of the shed columns determined the distance between each bent of piles and it was decided to use piles capable of supporting a load of at least 100 tons, including their own weight in water. This necessitated the use of piles 24″ x 24″ in section and required 33 vertical piles and six sloping piles in each bent. Two vertical piles and one sloping pile are driven beneath each side column of the shed, three vertical piles and one sloping pile beneath each interior column and the remainder of the vertical piles are spaced out between the column groups at approximately 10′ o. c. Of the six bracing piles three are driven with heads inclined to the north side of the pier and three to the south.

The amount of reinforcement in the piles varied in accordance with the length of the pile as cast, and was fixed by the amount required for their safe handling when being placed in position for driving. All piles under 60′ in length are reinforced with eight 1-in. round rods longitudinally, $1\frac{1}{8}$-in. rods were used for piles over 60′ and under 70′ in length and $1\frac{1}{4}$-in. rods for piles over 70′ in length. Lacing rods, $\frac{1}{4}$″ in diam., securely tied to the longitudinal reinforcement at 12-in. centers were used. All longitudinal reinforcing rods were continuous from end to end of each pile, no laps being allowed. The points of the piles are tapered for a length of 1′ 9″ and finished 3″ x 3″, being reinforced with four additional $1\frac{1}{8}$-in. rods and $\frac{1}{4}$-in. spiral hooping at 2-in. pitch. No metal shoes were used. Some additional stirrups were placed near the heads of the piles to prevent excessive breakage while driving and the longitudinal rods were allowed to project 3′ beyond the concrete to save the labor of cutting away the concrete in order to secure the necessary bond of the pile reinforcement with the concrete of the pier deck. A staple, made from $1\frac{1}{4}$-in. x $1\frac{1}{4}$-in. steel bar, was also cast into the head of the pile for use in handling the pile in the leads of the pile-driver. In order to minimize the bending moments in the piles during handling it was specified that all piles were to be lifted in such way that they were suspended at points $\frac{1}{5}$ of their length from each end while in a horizontal position. By the observance of the above rule the cracking of the piles while being conveyed from the molding yard to their ultimate position ready for driving was entirely eliminated.

The piles to be driven as brace piles were reinforced in a manner similar to that used for the vertical piles, but were cast with a camber, so that when built into the pier and under an axial load of 80 tons, the stresses on the cross-section of the concrete, due to this load, and the bending moment of its own weight would be uniform. The amount of camber required was determined by equating the moment due to the axial load into the unknown camber to the moment due to the weight of the pile in water.

$$\text{The camber equals} \; \frac{\text{The bending moment due to weight of pile after being driven in water at angle}}{160{,}000 \text{ lbs.}}$$

The above formula gives the camber required for a pile 45′ long as 2″ and $5\frac{1}{2}$″ for a pile 75′ long. Brace piles were placed so that their heads could be built into the dock beams immediately under a shed column so that all danger of a brace pile breaking through the pier deck was eliminated. The number of concrete piles used in the work is 1,801, 238 of which were driven at an angle as bracing piles.

The pier deck is built entirely of reinforced concrete carried on reinforced concrete girders 36″ deep which run transversely across the pier along the pile bents, and on girders of the same depth running longitudinally at an average of 9′ $10\frac{1}{2}$″ o. c. The 18-ft. by 9-ft. $10\frac{1}{2}$-in. rectangles thus formed are divided again by a transverse floor beam 24″ deep. The slab is 8″ thick reinforced in both directions with

½-in. round rods at 7″ centers, every alternate rod being bent up over the supporting beam.

All beams and girders are designed as T sections, sufficient web reinforcement being used to take care of the excessive shearing stresses, the top ends of the U stirrups being bent horizontally and carried into the slab as far as the table of the T extends, in order that the shearing stresses occurring between the web and table be properly cared for.

Owing to the side and the central railway tracks being carried at a level 3′ 6″ below that of the pier deck proper, transverse concrete gussets were built in at the four breaks in the floor level in order that the rigidity of the floor system would be maintained from one side of the pier to the other and the whole floor would act as a monolith in resisting the shocks of large vessels.

DESIGN OF PIER HEAD

A concrete beam 51″ deep is carried along each edge of the pier and to the outside of this is secured a rubbing fender of pitch pine with a vertical face of 20″. At the outer corners of the pier the depth of the fender beam was increased to about 11′, the corners being cut diagonally across, leaving a flat concrete surface 16′ wide by 11′ deep, strongly braced at the back by gussets from the pier floor. Numerous holes were left in this concrete face for attaching thereto fenders made up of birch or willow saplings, bound together into bundles. These bundles are made 10′ long and of various diameters from 24″ to 42″. Two layers of bundles are attached to each corner, the larger ones towards the middle, so as to form a rounded fender, the whole being bound in securely with three sets of steel cables.

Cast iron mooring posts of the mushroom head type are placed at 54′ centers along each side and each outer end of the pier. Each post is anchored down with eight 1½-in. round belts 30″ long, built into the concrete deck.

The interior columns supporting the upper floor of the shed are circular in cross-section, 25½″ in dia., reinforced with 1⅛-in. vertical rods and ¼-in. hooping at 1-in. pitch. vertical rods with ¼-in. facing at 6-in. centers.

The upper floor beam system consists of transverse girders supported on the six-columns of each bent, and longitudinal beams at 9 ft. 10½-in. The side columns are rectangular in section 16″ x 20″ reinforced with centers carrying a concrete slab 7″ in thickness. The transverse girders have a span of 39′ 6″ center to center of columns. In order to reduce the height of the upper floor above the pier deck to a minimum and at the same time to have adequate headroom for the lower story, the depth of the girders was made 50″ and the thickness of the floor slab was increased to 9″ for a strip of 18″ along each side of the girder to provide sufficient compression area. The horizontal reinforcement of the interior girders consisted of 17 1¼-in. square twisted bars, and the outer bay girders of 20 1¼-in. twisted bars. The heavy shearing stresses were taken care of by bending the ends of eight of the horizontal rods in each beam diagonally up at intervals as required and also by the addition of U stirrups. Knee-brace brackets are provided at the heads of all columns to insure lateral stiffness. The width of the girders was made 36″ to provide plenty of concrete for the proper bedding in of the large amount of reinforcing steel.

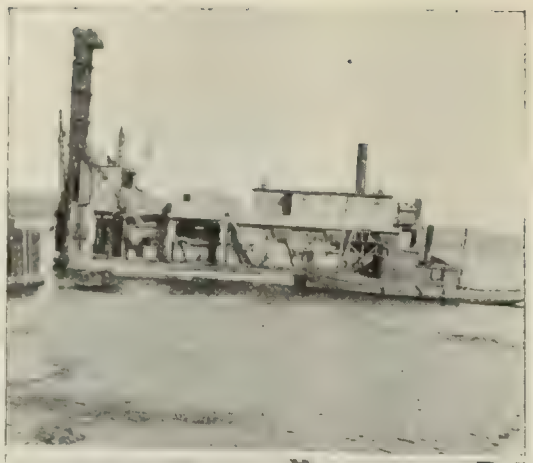


FIG. 8—SIDE VIEW OF PILE-DRIVER

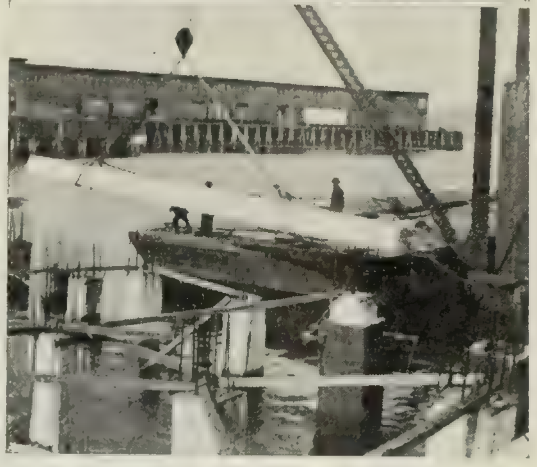


FIG. 9—SWINGING PILE INTO POSITION
Note straps are placed at points one-fifth of length of pile from ends

The longitudinal floor beams are 12″ x 27″ reinforced by 5.4 sq. in. of steel and U stirrups. The floor slab is reinforced with ⅝-in. rods at 6-in. centers transversely and ¼-in. spacing rods running longitudinally.

The roof consists of tar and gravel roofing laid on boarding and carried on a light reinforced concrete slab. The roof beam system consists of 12-in. x 42-in. transverse girders carried on 12-in. x 12-in. concrete posts, and 8-in. x 12-in. longitudinal beams with spans the same as those of the upper floor. The center bay of the roof is raised 5′ for the total length of the building thus forming a clearstory and providing good light for the upper story.

Steel sliding doors enclose each side of the lower story, except for a length of 72′ at the shore end which is given over to shipping and railway offices. On the upper floor a 17-ft. wide opening closed with two steel sliding doors, is provided at 36-ft. centers. All sliding doors for both floors are provided with windows glazed with ribbed wire glass.

The two end walls of the shed are of reinforced concrete. The entrance for the two central railway tracks through the west end wall, 33′ wide by 18′ high, is provided with a rolling steel slat door, as are also the 18′ wide roadway entrances. All window frames are of steel glazed with wire glass.

There are no expansion joints in either the pier deck or the upper floor, but as the upper story is to be temporarily used for an immigration examination building and will be heated during the winter months it was thought advisable to leave expansion joints in the roof, so as to relieve the bending stresses which would occur in the columns towards the ends and sides of the building.

Transverse joints are made by simply leaving a ½-in. space midway between two bents of columns, the longitudinal beams thus cut being designed as cantilevers. Where it was necessary to have an expansion joint to guard against transverse expansion, it was made by having the north end of the clearstory girders rest on steel plates and rollers.

In order to secure additional yard room at the base of the pier, the old bulkhead of the Cunard pier had to be abandoned and a new bulkhead built. This new bulkhead was erected 250′ east of the east side of Water St., and was formed of timber cribwork filled with rock and sand, all outside faces being of squared timbers sheathed with creosoted planking. After the work was begun it was decided further to widen the yard and an additional 106′ of yard room was obtained by the construction of a reinforced concrete wharf similar in construction to the pier deck. The length of the pier was thus reduced to 694′ from the new bulkhead line.

CONSTRUCTION WORK

The contract for the construction of the pier and shed was let to the Nova Scotia Const. Co., Ltd., of Sydney, Cape Breton, in Sept., 1911. Work was immediately begun on the clearing of the site and the removal of the old piers, which turned out to be a somewhat tedious task on account of the large number of short stumps of piles which had to be removed by the help of a diver. These stumps were the remains of old piles which had been gradually eaten through by limnoria below low-water level. During this part of the work it was found that the damage done by limnoria to uncreosoted timber extended from about 5′ above extreme low water down to the level of the mud, even when that was 30′ or more below low water level. Several creosoted hard pine piles, which had been in the water about 4 yrs. were found to have been attacked and eaten into about ½″. No signs of the toredo navalis were seen on any of the old piles. As soon as the site had been cleared the dredging for the bulkhead crib seats and the building of the cribwork was begun and carried on throughout the summer of 1912.

Casting the Piles.—Meantime the contractors had been preparing their pile-making yard. A level area of sandy beach, about 7 mi. by water from the site of the new pier, had been leased and graded. At the back of this level area were large deposits of gravel and coarse sand, which on examination proved to be mostly composed of quartzite, cubes and briquettes of mortar made from this material and cement easily passing the limits of strength required by the specifications which were based on those of the Can. Soc. of C. E.

The molding yard measured 800′ in an east and west direction by 600′ wide. A gravel excavating, crushing and concrete mixing tower was erected at the east end of the yard, mounted on wheels which ran on tracks across the whole width of the yard. Parallel tracks were laid across the west end of the yard on which an anchor tower, similarly mounted on wheels, was placed and a cableway stretched between the two for conveying the concrete to the pile molds.

On top of the main tower, 80′ above track level, was placed a winding winch operating a drag-line excavating bucket. This bucket emptied its contents of sand and gravel into a hopper over a grizzly, all stones not passing through being conveyed to a jaw crusher. The material was then passed over ¼-in. and 1-in. screens to separate the sand from the stone, any stones not passing through the 1-in. screen being elevated to a second crusher.

Chutes from the stone and sand bins led the materials to the mixer platform, where they were measured before passing into the mixer. The concrete mixer was a 1-yd. cylindrical revolving mixer which discharged each batch into a bottom dumping bucket which traveled along the aerial ropeway to the pile molds.

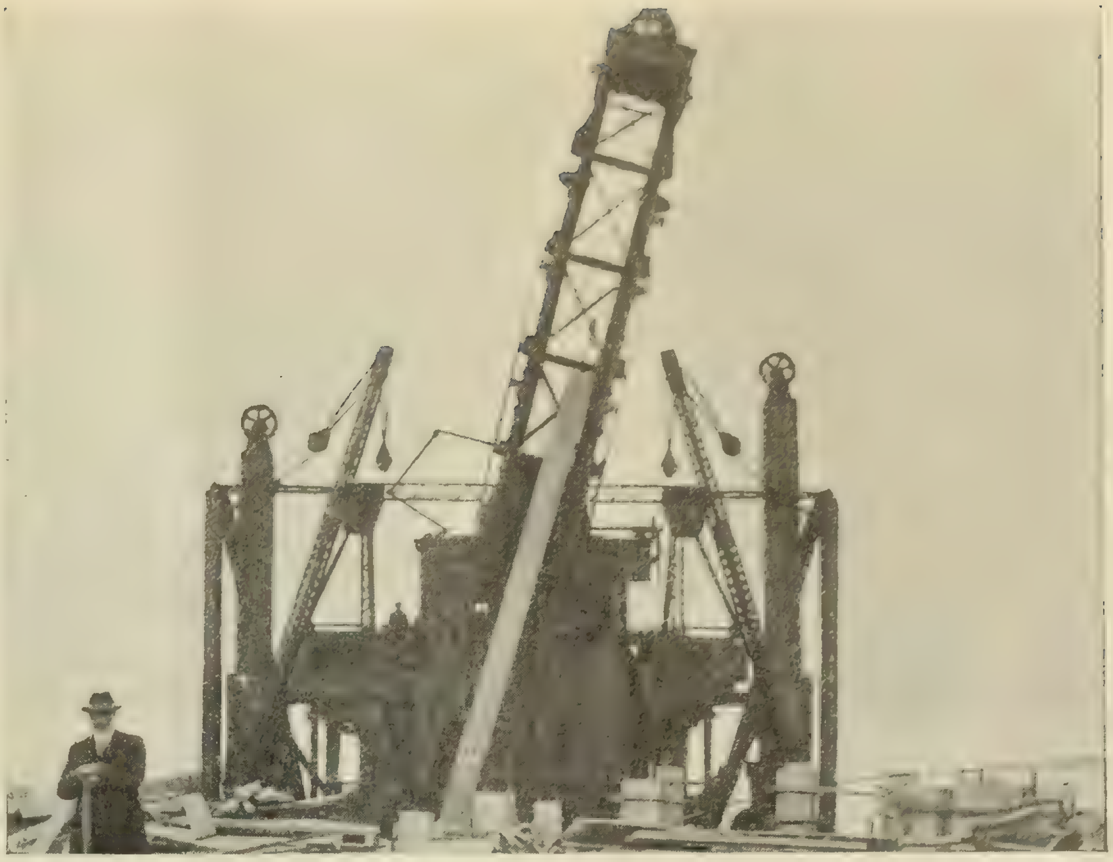


Fig. 10—Pile Being Driven Into Position By Pile-Driver Derrick

Note brace pile driven at an angle to the vertical

The pile yard was divided into 10 sub-yards running north and south. In each sub-yard two railway tracks were laid so that the distance between their center lines was approximately equal to ⅗ of the average length of the piles to be made in that sub-yard. The molds for the piles were put up in pairs with their axes east and west, parallel with the cableway, and placed so that about ⅕ of the length of the mold extended on each side of the tracks along which the lifting cars would run.

Once the concreting of a pair of piles was begun, no stop was allowed before they were completed, so that all joints in the concrete were eliminated. The first pile was concreted May 21, 1914, and all were completed by Dec. 17, of the same year. The maximum amount of concrete poured by this plant in a day of 10 hrs. was 168 cu. yds.

A timber pier, 1,000′ long by 22′ wide except for 85′ at its outer end where its width is increased to 38′, carrying one railway track and a 30′ ton loading derrick at its outer end, was built at the west end of the pier, extending westwards into the harbor. This pier is also equipped with stone and sand storage bins.

Handling the Piles.—Owing to the weight of the concrete piles, the smallest of which weighed 12 tons and the largest 28 tons, conveying them to the site of the work presented certain difficulties. The railway track from the loading pier was continued along the north side of the yard intersecting the north ends of each of the sub-yard tracks. Counterweighted cars with projecting ends were used for bringing the pile to the pier track. These cars were furnished with heavy screw-jacks on their overhanging ends, by which the pile was raised off the mold bottom and laid between the two rails of the longitudinal track. It was there raised up under two cars which straddled the pile and pushed out to the pier head where the derrick lifted it onto a scow for conveyance to the new pier. The scows used were capable of taking nine piles on each trip.

The Pile-Driver.—Designing and building a pile-driver capable of handling and driving such heavy piles in exact position, both vertically and on an angle, took much longer than it was at first thought it would, and it was not until the Jan. 1, 1913, that the first pile was placed.

A floating driver was used designed by Messrs. Mussens of Montreal and the Bucyrus Steam Shovel Co.[2] who designed and supplied the machinery operating the pile leads and spuds.

The scow carrying the pile-driver was built by the Nova Scotia Cons. Co. at Liverpool, N. S., and measures 112′ long by 56′ wide over all. The scow is fitted with three spuds for holding it in position. The two forward spuds, which have to carry the weight of the pile and the greater part of the machinery, are 36″ x 33″ in cross-section and 96′ long over all, with lower ends shod with cast steel shoes. These spuds are operated by individual winches which can force them down as well as raise them. The stern spud, which is of similar length but only 27″ x 27″ in section cannot be forced down. The spuds are each made from four sticks of B. C. fir, each stick being the whole length of the spud.

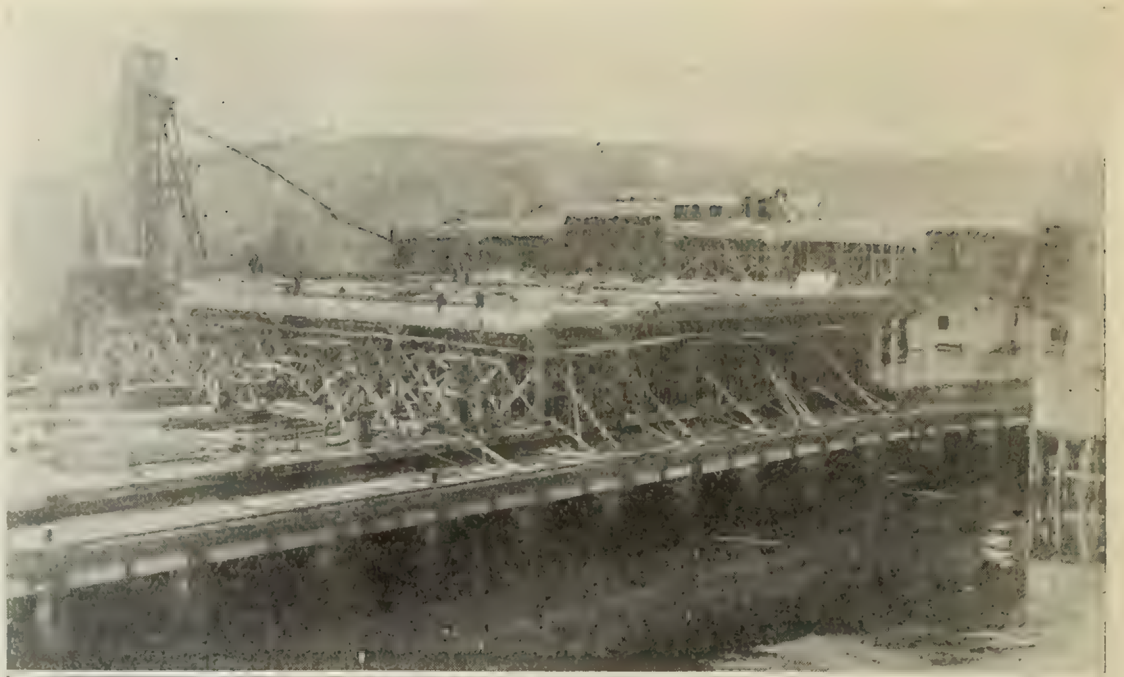
In order that the piles could be placed accurately in the positions required by the plans, the pile leads were hung on a carriage traveling on rollers which gave it a forward movement of 7′, while the leads themselves can be traversed across the face of the carriage 4′ on each side of the center line.

The pile leads, which are built in the form of a three-sided box girder, are 75′ in length and weigh about 72,000 lbs. Over pulleys on top of the leads pass the cables for handling the piles, the pile-guiding fingers, and the pile-hammer. The hammer runs in guides on each side of the leads which are designed with a switch at the top so that the hammer can be run into the leads, thus allowing the pile to hang vertically in front.

In order that the brace piles may be driven the leads are pivoted at the center of their length, and their lower ends can be carried over 8′ to either side of the center, by operating a long threaded horizontal shaft, thus allowing the leads to be canted at the angle required for these piles.

On each forward corner of the scow, a 30-ton derrick crane is placed for lifting the piles and conveying them in front of the driver. Each derrick has its own steam winch.

One engine, carried on the pile leads carriage, operates the pile-fall, hammer-fall, pile-guide fall, stern spud-fall and the backward and forward travel of the leads carriage. The traversing and canting of the leads are done by a small engine placed on the forward part of the carriage.



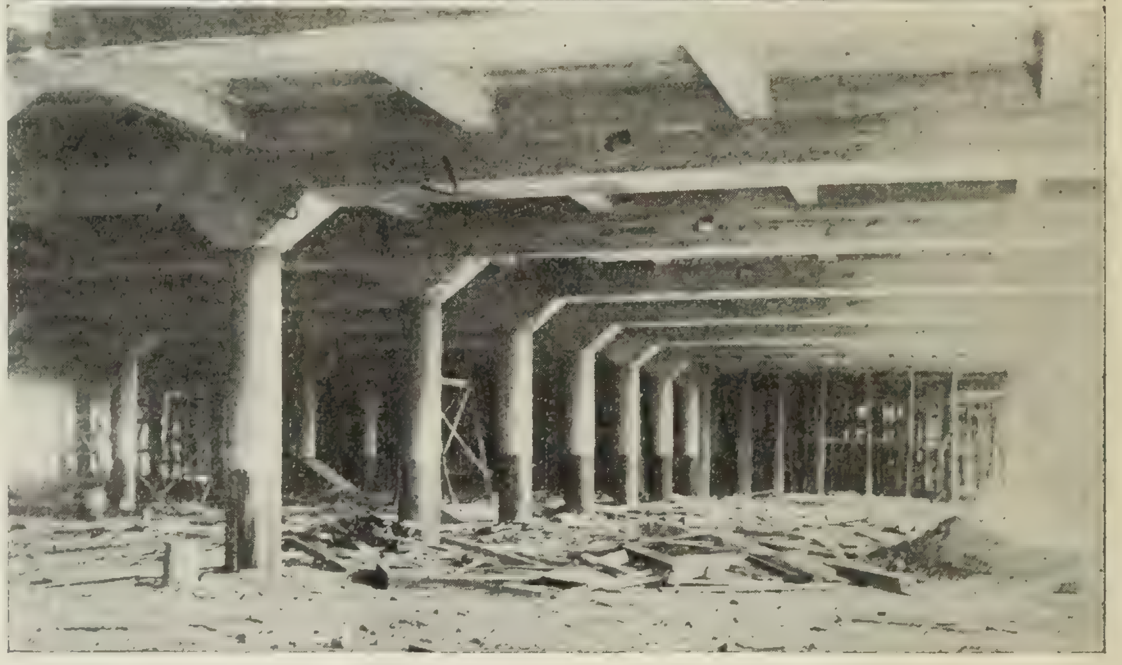


Fig. 11—Forms for Pier Shed

Note raised clearstory on roof, also frost protection planking on piles between tide levels

Fig. 12—Detail of Shed

Note steel protecting plates on columns, also holes left in girders for electric wiring conduits

The pile-hammer used was a double acting steam hammer of the Arnott type. The weight of the piston and ram is 4,150 lbs. The diam. of the piston head is 14″ and the stroke of the hammer 36″. The total weight of the hammer, including side guides and lower casing, is a little over 16 tons. With a steam pressure of 80 lbs. it is designed to work at the rate of 80 blows per min. Owing to the fact that this was the largest hammer of its kind ever built, considerable trouble was at first experienced in its use, due to the frequent breakage of parts, especial difficulty being found in preventing the hammer head from working loose on the piston rod.

A 250-h.p. Scotch marine type boiler supplied steam for all the machines, including the hammer.

Placing the Piles.—The method followed in placing and driving a pile was as follows: The pile-driver scow was first placed in position by means of cross-ranges and anchored by lowering her spuds. Straps were placed around the pile to be driven as it lay on the deck of the scow on which it had been brought up from the yard, and the pile was lifted horizontally by one of the forward derricks and swung around in front of the driver so that the head of the pile came in front of the pile leads. Swinging the pile was accomplished by manipulating the forward spuds of the pile-driver scow. The pile-fall, having been made fast to the staple projecting out of the head of the pile, was hoisted up and at the same time the derrick-fall was lowered and the pile gradually raised into a vertical position, the straps around the pile being taken off as the strain came off them. The pile leads were then moved as required for the exact centering of the pile. On the pile being lowered it penetrated with its own weight the overlying soft mud. This mud was found to have sufficient stiffness to hold the pile vertically when its depth was about equal to ⅓ of the length of the pile; as a general rule, however, the piles had to be stayed while the hammer was being adjusted on their heads.

Three separate cushions were used between the head of the pile and the ram of the hammer. On top of the pile was first placed 3″ of spruce plank; on this rested a cast steel follower about 4′ in height, design-

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[2] Bucyrus Co., S. Milwaukee, Wis.

ed to protect the projecting reinforcing rods and staple. This follower consisted of a hollow steel cylinder with top and bottom flanges. The bottom flange was flat and provided with holes through which the projecting rods passed, by means of which the pile was firmly held while being driven. The top flange had a rectangular depression on its upper side in which was placed a hardwood block about 15″ thick, bound round with steel bands. This block received the direct strokes of the hammer and had to be very frequently renewed. At times one of these blocks would break up after the driving of only two piles while others would stand the hammering of 20. The breakage of the steel band was the usual cause of failure, although at times the heart of the block would become charred owing to the heat generated by the force of the blows.

The amount of hammering which the piles required to drive them to refusal varied a great deal. In some places where the depth of the hardpan was small the pile would come to a stop after 200 blows to 300 blows. while in other places they would require nearly 1,800 blows to drive them to rock. The rate of penetration through the hardpan was small, the last foot or so in many cases being penetrated at not more than 1/30″ per stroke.

The following are records of the driving of three piles, which show the great variation met with:—

1.	Number of strokes of hammer.....	1,010
	Total amount of penetration.......	107″
	Average penetration per blow......	.10″
	Average penetration per blow during last ft.	.033″
2.	Number of strokes of hammer......	505
	Total amount of penetration........	37″
	Average penetration per blow......	.073″
	Average penetration per blow during last ft.	.036″
3.	Number of strokes of hammer......	240
	Total amount of penetration.......	23.2″
	Average penetration per blow......	.10″
	Average penetration per blow during last ft.	.059″

Very little damage was done to the piles by the hammering. Only two piles had their heads badly smashed. These were among the first few piles driven, and the cause of the shattering of the piles was the continuation of the hammering after the pile had reached rock. A few blows of the hammer given to the pile after penetration had stopped did no damage. In a few cases pieces of concrete was knocked off the top edges of the pile head, usually due to a tendency of the pile to drive to one side or the other, thus making the hammer bear unevenly on the head of the pile.

To determine what was taking place at the point of the pile, several piles were pulled up after having been driven to refusal. Out of nine piles thus pulled and examined only one showed any damage and in that case the pile had encountered a sharp point of rock which had entered the concrete point of the pile and spalled a small piece off the corner.

When no machine troubles were met with an average of 10 piles could be set and driven in 10 hrs. In some weeks, however, the average slightly exceeded 12 per da. and the best day's work was 18.

In order to test the bearing power of the piles after driving load tests were made with a floating load of 180,000 lbs. on certain piles. The load, which consisted of two scows of 90,000 lbs. weight each, was attached to the ends of a steel girder resting on the head of the pile and made fast at high tide, the pile and the load being securely braced to prevent swaying of the pile when under load. On the tide falling the whole load was carried by the pile. Tests were made on piles which had been driven to different degrees of penetration with the following results:—

Pile going 1/10″ per blow, settlement under load 1/15″.
Pile going 1/5″ per blow, settlement under load 1/20″.
Pile driven to refusal, settlement under load nil.

The Deck Forms.—The problem of building forms of the necessary strength and stiffness on the short length of pile projecting above the water was not an easy one but was successfully solved by the contractors. Four-in. x 8-in. horizontal walings were bolted on each side of the piles as soon after driving as possible, and on these were erected the vertical forms for the building up of the pile to dock level. The bottoms of the beam forms were carried on joists supported by the pile extension forms and braced by diagonal shores from the pile walings. Slight settlement of the forms took place on the pouring of the deck concrete, but in no case did any failure occur. It was found that by filling the pile extension forms at least 24 hrs. ahead of the pouring of the deck, the settlement of the forms was reduced considerably.

PLACING THE CONCRETE

As the work was of such large area, joints had to be allowed between successive days' work. No joint was allowed between beams and slab, the slab being poured immediately after the beam or girder supporting it. The usual practice of leaving a vertical face perpendicular to the compressive stresses in the concrete at the location of the joint was always followed, the joint being located where the shearing stresses were a minimum. In the case of the girders which carried a floor beam at the center of their span, the joint had to be made to one side of the center at a point where shearing stresses would occur The joints at these places were made with a horizontal seat to give bearing to the longer part of the girder, and so placed that some of the diagonal reinforcing rods passed through the joint.

The concrete used in the construction of the pier deck and shed was mixed in the proportion of 1 part Portland cement, 2 parts sand and 4 parts 1-in. crushed gravel. Batch mixers were used throughout and the concrete was distributed from an elevator tower by chutes. Special care was taken to embed properly all reinforcing steel, concrete made from a finer crushed stone being used where found necessary.

The surfaces of the floors are finished with a finishing coat of 1:2 coarse mortar troweled to a fairly rough surface. The lower floors were built with a fall towards the railway tracks of 4″ in 45′.

Special provision had to be made, when finishing off the pier deck in Dec., 1913, so that the remainder of the pier might be added in the following year without there being a line of weakness. This joint was made immediately over bent No. 39, the heads of the piles in this bent being built out so as to provide bearings for the west ends of the girders spanning between bents 39 and 40. Additional reinforcing steel rods were introduced and hooked so as to tie together the two portions of the pier.

Work was begun again in May, 1914, and the whole of the concrete work completed by Dec., 1914, and the lower story of the shed is now in full use. The upper story is at present being fitted up for the temporary examination of immigrants and was ready for use in March of this year.

PERSONNEL.

Contract for the construction of the pier and shed has been carried out by the Nova Scotia Cons. Co. under the management of Hamilton Lindsay, assisted by J. Shepard Lee, B. S. John Kennedy, M. I. C. E., is Cons. Eng. for the Dominion Govt. for the work and was assisted in the design by A. F. Dyer, A. M. I. C. E., who has acted as resident Engr. on the construction, assisted by R. A. Lockerby, B. Sc. The cost of the work complete was estimated to be about $1,125,000.

Design and Construction of Mass. Institute of Technology Buildings

By Sanford E. Thompson[1]

Interesting design and construction features of the Technology buildings were discussed in an address from notes by Mr. Thompson at the Chicago Convention, Feb., 1915, of the Am. Concrete Inst. The article has only recently been completed and is now presented with its numerous illustrations.

The tests made indicate why reinforced concrete so often is able to endure stresses far beyond the loading for which it was designed.

A table showing detailed study of the cost of different types of floor construction is particularly valuable.

The construction of the new buildings of the Massachusetts Institute of Technology represents one of the most comprehensive schemes, for an educational institution, that has been developed in this country. Standing upon an area of 50 acres, the buildings themselves cover an area of 3½ acres, and if placed in a straight line would extend some 2,500′ in length. Except the stairways, which will be of structural steel, reinforced concrete is being used throughout, and about 40,000 cu. yds. of concrete and 3,600 tons of steel reinforcement will be required.

The main subject of this paper is the structural features of the work, more especially the engineering studies and investigations that determined them. In connection with a general description of the layout of the work, however, the more interesting construction details are taken up.

ARRANGEMENT OF BUILDINGS

The complete plan provides for over 30 buildings with 17 of the larger and more important grouped around a central court and so arranged and constructed as to form one continuous building (see Fig. 1).

More academic buildings will be erected in the rear of the present structure, on Vassar St., when the money available and the number of students warrant. At present only the 13 buildings shown in full lines in Fig. 1 are being erected, but plans for all those shown dotted are well under way.

Buildings facing directly on the major and the minor court (see Fig. 4) and on the important streets are faced with Indiana limestone. On the secondary courts and other less prominent places pressed brick is used.

Buildings on the major court have four stories and those on the minor courts three, but on these latter are two pavilions, one on either side of the main entrance from the street, that run up to the fourth story.

CONSTRUCTION DETAILS

The size of the job made it convenient for construction purposes to group the buildings into seven sections, A to G inclusive. (See Fig. 1.) Each section has its own organization, with field office, mixing plant, etc.

Materials are carried direct by switch tracks from the Boston & Albany R. R. on trestles to each mixing plant. Sand and gravel are dumped under the trestle into pits holding respectively 300 cu. yds. and 400 cu. yds. Cement is stored in houses, one for each plant. The ¾-yd. mixers are located in pits so that all materials are fed by gravity. The mixed concrete is poured into cars which are run up an inclined track to the hoist towers. These towers are located in a central position so that the concrete can be hoisted and distributed through chutes to the various sections. The mixed concrete is not, however, chuted directly to place, and therefore this source of danger of poor concrete is avoided. It was found, in order to handle the concrete by chutes and at the same time maintain the proper consistency, that it was necessary to limit the slope of the chutes to 30° with the horizontal. This slope is therefore maintained and the concrete flows from each chute into a hopper and from this hopper it is poured into 2-wheel Ransome[2] barrows and wheeled to place. Tests of specimens of the concrete taken at different points in

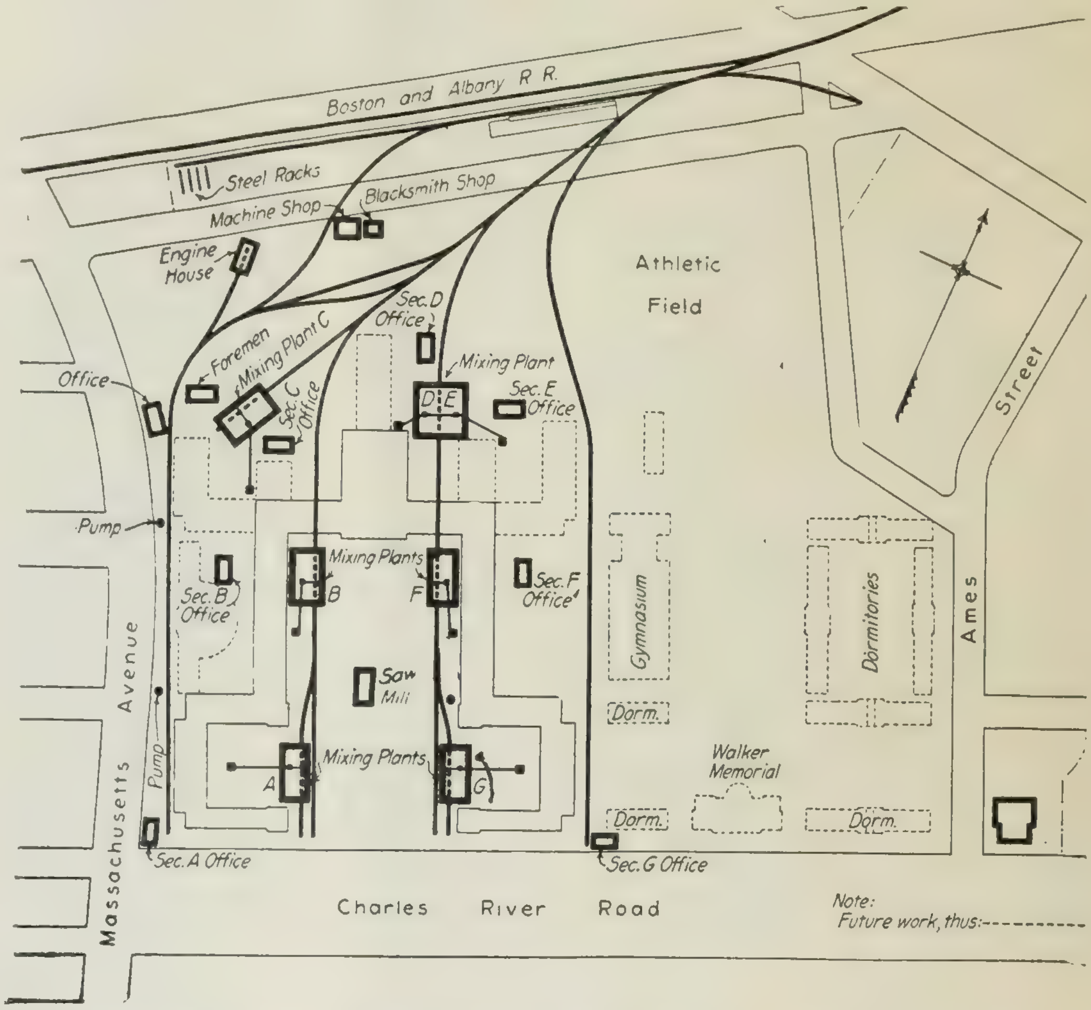

Fig. 1—General Layout of Permanent Buildings and Construction Plant

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[1] Cons. Engr., Boston

[2] Ransome Concrete Mchy. Co., Dunellen, N. J.

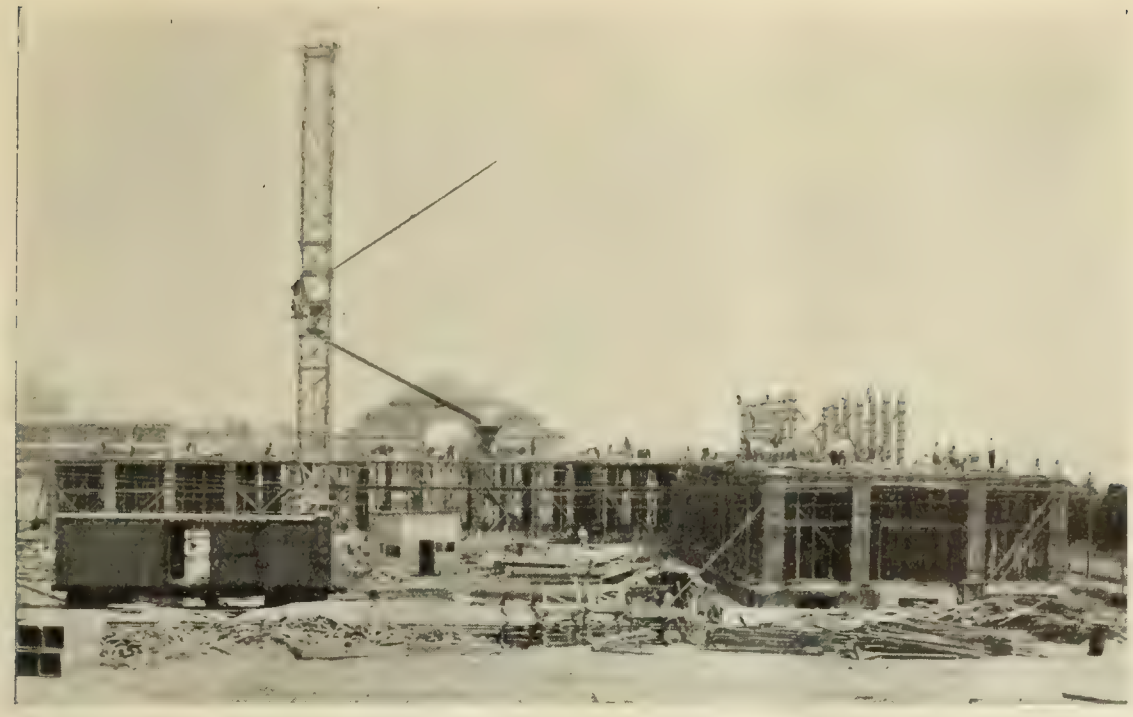

Fig. 2—Typical Arrangement of Tower, Chute and Hopper

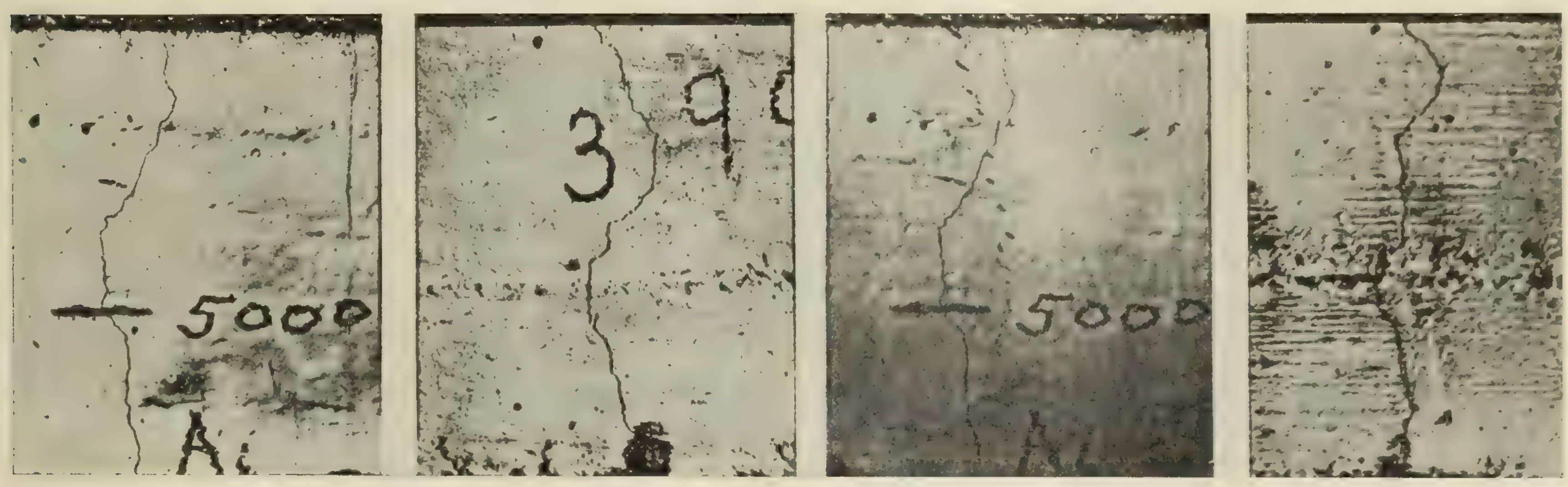

Fig. 3—Characteristic Cracks in Beams Reinforced With Plain and Twisted Steel

Photographs represent very much higher stresses than at working loads because they show cracks at actual and not at theoretical stresses, the latter taking no account of assistance of concrete in tension

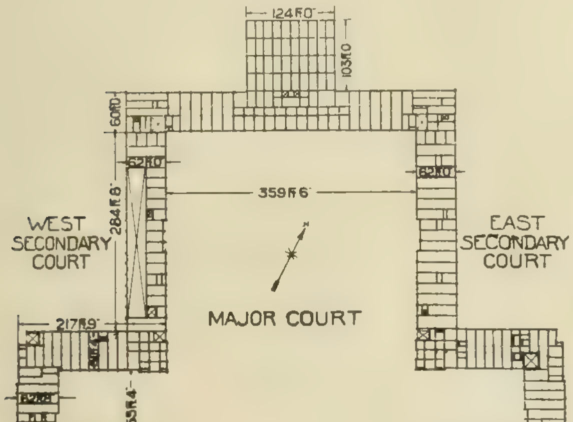

Fig. 4—Arrangement of Building Under Construction and Framing Plan of Second Floor

the system indicated that the strength was increased rather than diminished by flowing through a chute in this manner. The chuting on a uniform slope also requires a smooth mix of uniform consistency which will not separate. (See Fig. 2.)

MATERIALS, TESTS AND STRESSES

Concrete Materials and Tests—Although eastern Massachusetts is largely covered with glacial deposits of sand and gravel, it is by no means easy to find materials that make first-class concrete. Available sources of supply were sampled and tested before placing the contract for aggregates and finally a new bank located about 12 mi. from the site was opened and the contract made for excavation, screening and delivery.

Immediately after deciding on the aggregate, compression tests of cylinders 8″ in diameter by 16″ long were made to determine the best proportions and allowable stresses. As a result three mixes were chosen, proportions 1:2:4, for the footings and foundation walls, 1:1½:3 for the superstructure, and 1:1:2 for a few important columns that required especially high stresses.

Universal[3] Portland cement is used and is tested regularly at the mill, with check tests at the author's laboratory.

As sand tests are fully as important as cement tests, the inspector goes to the bank at regular intervals for samples of sand which are sent to the author's laboratory for testing. The specifications require a ratio to standard sand of 70% for 3 das. and 85% for 7 das. Although this is somewhat lower than the Joint Committee recommendations, it was found that the aggregate produced concrete of the required strength and furthermore the values could be used as absolute minimums on short time tests. As a matter of fact, the tests thus far have averaged 91% for 3 das., 100% for 7 das. and 102% for 28 das., an excellent record, especially for New England sands.

Field Tests—Two field samples of concrete are taken regularly on each section of the job at least four times a week for test at 14 das. and at 28 das., both samples from the same batch in order to arrive at the true relative value. Whenever possible the samples are taken directly from place, but for beams, columns and girders this was impossible, and

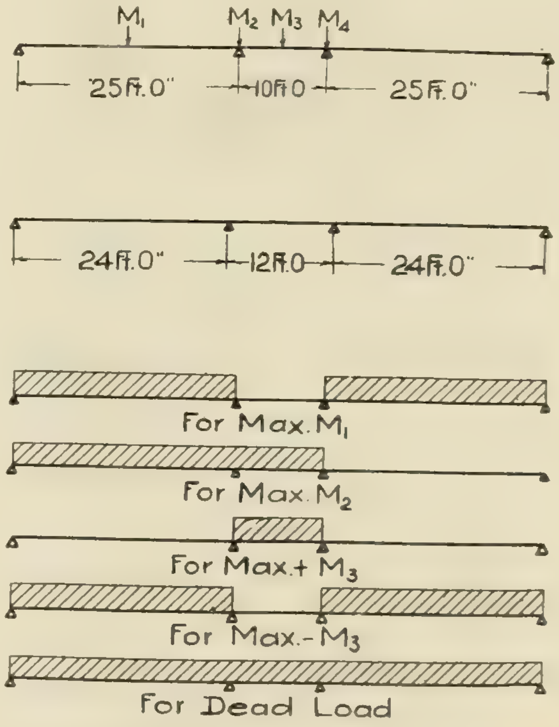

Fig. 5—Typical Beam Arrangement

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[3] Universal Portland Cement Co., Chicago

samples are taken from the barrow before placing. The concrete is shoveled into two 14-qt. galvanized iron pails, carried to the molding yard, remixed to eliminate the segregation of materials due to carrying from the work and poured into iron molds embedded in moist sand. The maximum and the minimum temperatures are recorded every day. For mass concrete where the aggregate runs up to 2″ or 2¼″, samples are cast in cylinders 8″ x 16″, but for the superstructure concrete, where the largest sized aggregate is not over 1½″, 6-in. x 6-in. x 12-in. prisms are used because the material for the larger size of specimen was too heavy to carry down from the upper stories. The bottom of each mold was formed by a ½-in. iron plate. The concrete is tamped in the mold with a 6-in. ice chopper, taking about the same precautions as are employed on the regular work. Each sample is given one tamp on each face and four tamps at 90° in the center. The time of the operations of dumping into the molds and tamping never exceeds 5 min. Just previous to the initial set the top surfaces are carefully troweled with a plasterer's trowel in order to obtain uniform bearing for the compression machine. After 48 hrs. the blocks are taken out of the sand, removed from the molds and reburied in the moist sand where they remain until the day before testing.

Results of Tests—The average results of these concrete compression tests are as follows:

1:2:4 concrete, 14 das. old	1,640 lbs.
1:2:4 concrete, 28 das. old	2,110 lbs.
1:1½:3 concrete 14 das. old	2,008 lbs.
1:1½:3 concrete 28 das. old	2,520 lbs.

Each value is an average of about 90 specimens and the per cent of variation from the mean runs much lower than is usual in construction work, because of the care with which the samples were taken and molded.

The increase in strength from 14 das. to 28 das. for the 1:2:4 concrete has averaged 23% and for the 1:1½:3 concrete 25%. The series of laboratory tests conducted last year by the Institute Committee on Aggregates showed an increase of 19% in this period.

The practical value of this system of sampling and testing was shown at the beginning of the job. Some of the specimens of 1:2:4 concrete gave low test. The method of handling the concrete on the job was changed at once and subsequent specimens gave proper strengths. To be sure that the concrete that had been previously placed was satisfactory, three or four samples were cut out of a solid footing 3 wks. or 4 wks. old. After being sawed to a standard 8-in. x 8-in. x 16-in. size, they were crushed and the strengths averaged 2,200 lbs., a satisfactory figure for this portion of the structure.

Properties of Reinforcing Steel—The cold twisted steel used for reinforcement was tested at the mill with the following results:

Yield point varied from 57,000 lbs. to 64,000 lbs. and the tensile strength from 70,000 lbs. to 81,000 lbs.

Elongation in 8″ was 7½% to 10% and reduction in area was 33% for the larger sizes of bars and 15% elongation with 50% reduction in area for sizes below ½″.

The fracture was a half cup.

Bending tests for ½-in. and larger bars were 180° around their own diam. and for bars below ½-in. 180° flat.

Phosphorus ranged from .01% to .02% and sulphur from .03% to .04%.

Beam Tests—Stresses were so chosen that no cracks would be visible under ordinary working loads and before coming to a decision on these stresses full-size T-beams were made and tested.

As a result of the tests it was evident that the cracks in beams reinforced with twisted steel are less objectionable under a steel stress of 18,000 lbs. per sq. in. than cracks in beams reinforced with plain round bars under a stress of only 16,000 lbs. per sq. in. Moreover, so much of the tension was carried by the concrete that with a theoretical stress of 18,000 lbs. the actual measured stress is only 8,000 lbs. In beams reinforced with twisted steel there were many more cracks than in beams reinforced with plain round bars, but these cracks were all small and well distributed and therefore unobjectionable, whereas in the plain round bar beams the cracks were larger and more noticeable.

Fig. 3 A and B, shows full-size portions of cracks in two beams reinforced with plain round and with twisted bars. The crack on the right, Fig. 3a, was produced by a 16,000-lb. unit stress in the round steel and that on the left by an 18,000-lb. stress in twisted steel.

Fig. 3B shows full-size portions of cracks in two beams reinforced with plain round and with twisted bars but carrying about double the stress carried by the beams in Fig. 3A. The crack on the right was caused by a 31,000-lb. unit stress in the round steel and that on the left by a 33,000-lb. unit stress in the twisted steel. The stress of steel at failure for beams with twisted steel averaged 93,000 lbs. per sq. in. and for beams with plain round bars 60,000 lbs.

DESIGN

Complete specifications, following substantially the recommendations of the Joint Committee on Concrete and Reinforced Concrete, were drawn up by the author. Only special features are considered in this paper.

UNIT STRESSES

The following standard unit stresses are based on the compressive strength of 8-in. x 16-in. concrete cylinders tested in the laboratory, using the percentages for different kinds of stress recommended by the Joint Committee on Concrete and Reinforced Concrete.

Item	1:2:4 concrete	1:1½:3 concrete	1:1:2 concrete
Compressive unit strength of concrete in 8-in. x 16-in. cylinders	2,000	2,500	3.300
Compressive fiber stress at center of beam	650	810	
at support	750	930	
Compressive stress	450	560	750
Shearing unit stress	120	150	
Bond stress	80	100	
Ratio of elasticity	15	12	10
Steel tensile stress	18,000	18,000	18,000

TYPICAL BENDING MOMENTS

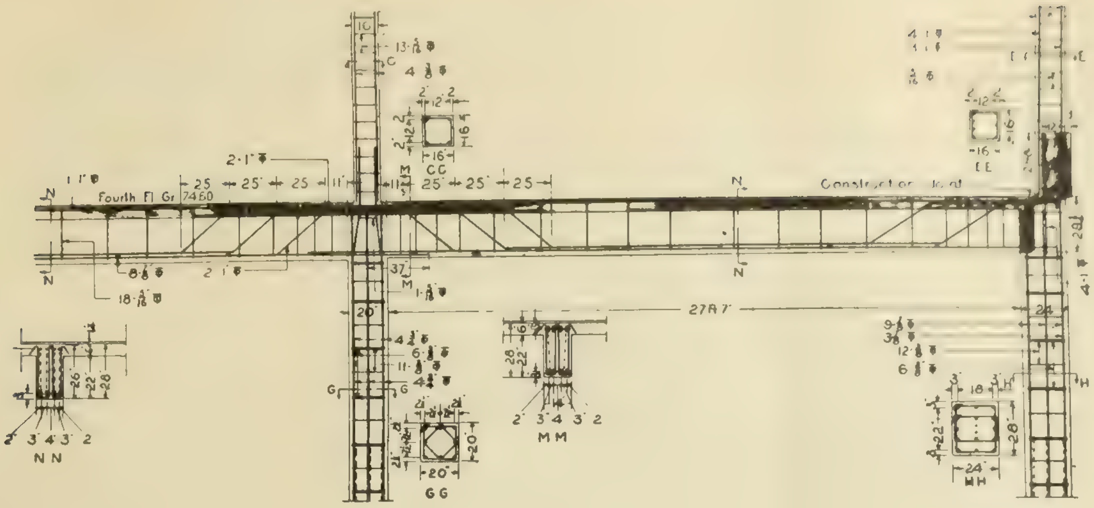
In the layout of the beams (see Fig. 4) there is usually one short span between two long spans. This arrangement gives a series of class rooms on each side of a long corridor, with most of the beams in the partition.

The line drawing, Fig. 5, shows the positions of live and dead load for maximum bending moments for this type of beam. The formulas from which the bending moments are derived are rather complicated and involve integral calculus. Solutions were worked out for the different conditions and constants obtained, by use of which the general formulas were reduced to the simple ones given below.

Let

M_2 and M_4=Bending moments at center supports

mx_1 and mx_3=Static bending moment at any point in the respec-



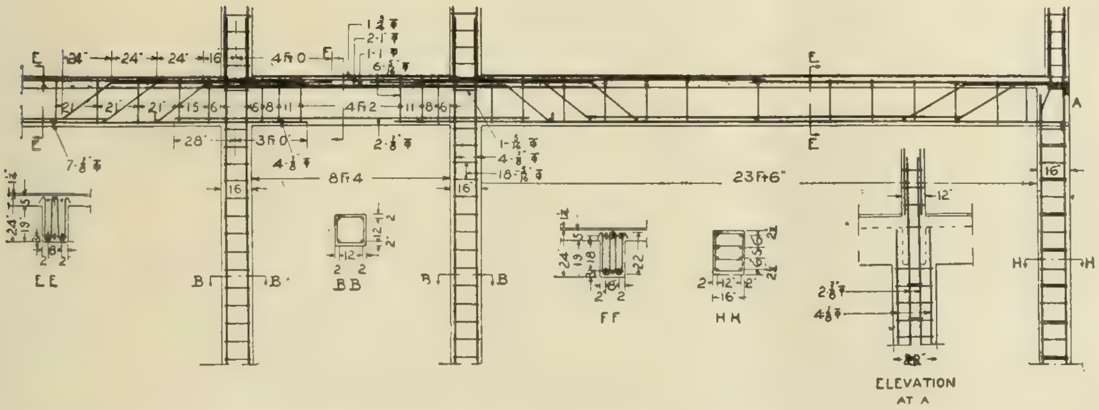


Fig. 6—Typical Beam and Column, Building on Minor Court

Fig. 7—Typical Beam and Column, Building on Major and West Secondary Courts

tive end span due to load in that span

mx_2=Static bending moment at any point in the center span due to load in that span

s= ratio of end span to center span

$$2M_2(l+nl)+M_4nl=-6\left[\frac{1}{l}\int_0^l m_{x_1}x\,dx+\frac{1}{nl}\int_0^{nl} m_{x_2}(nl-x)\,dx\right]$$

$$M_2nl+2M_4(nl+l)=-6\left[\frac{1}{nl}\int_0^{nl} m_{x_2}x\,dx+\frac{1}{l}\int_0^l m_{x_3}(l-x)\,dx\right]$$

These formulas were solved and constants in terms of dead and live loads derived for different ratios of short span to long span and for different positions of the load.

For design as a result of these studies, the following simple formulas were used for the three span continuous beams:

End spans: Center $M_1 = \frac{1}{11}wl^2$

Support $M_2 = -\frac{1}{11}wl^2$

Center spans:

Support $M_2 = -\frac{1}{11}wl^2$

$M_3 = \frac{1}{60}wl^2$

Middle

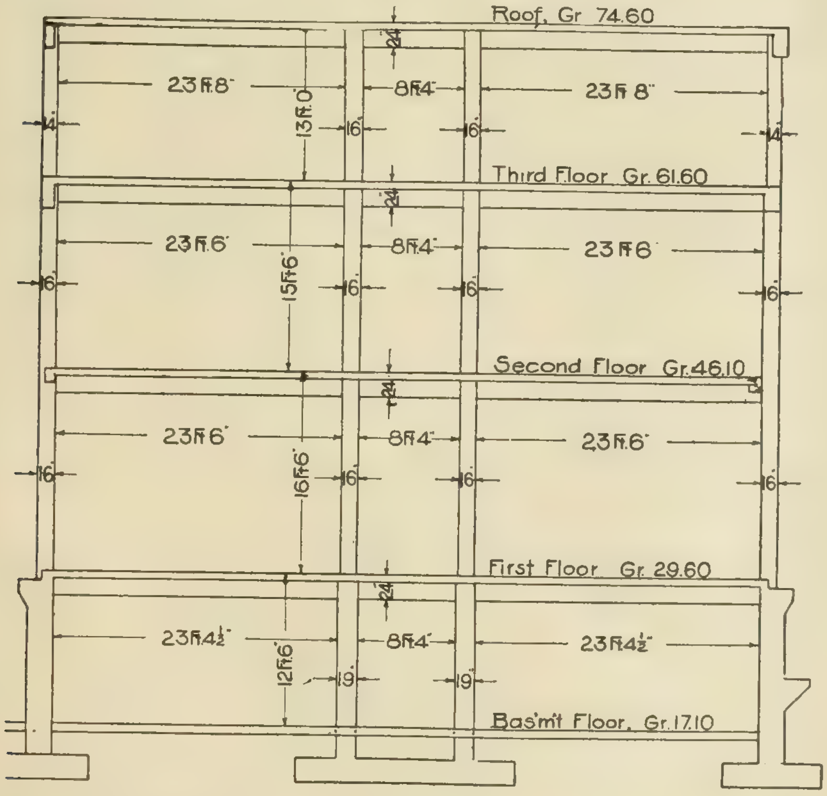
$M_3 = -\frac{1}{18}wl^2$

In all above cases, l is the length of the end span.

RELATIVE ECONOMY OF DIFFERENT ARRANGEMENT OF BEAMS AND GIRDERS

Before deciding on a flat slab layout with no intermediate beams, requiring 15-ft. x 27-ft. slabs, studies were made of the relative costs of this construction compared with intermediate beam and tile construction. The long span concrete slab construction proved most economical, however, when the total cost of concrete, steel and making of forms was considered. Designs and estimates were made for the following cases:

Case I—Panel with no intermediate beam; slab 15′ 6″ solid concrete construction.



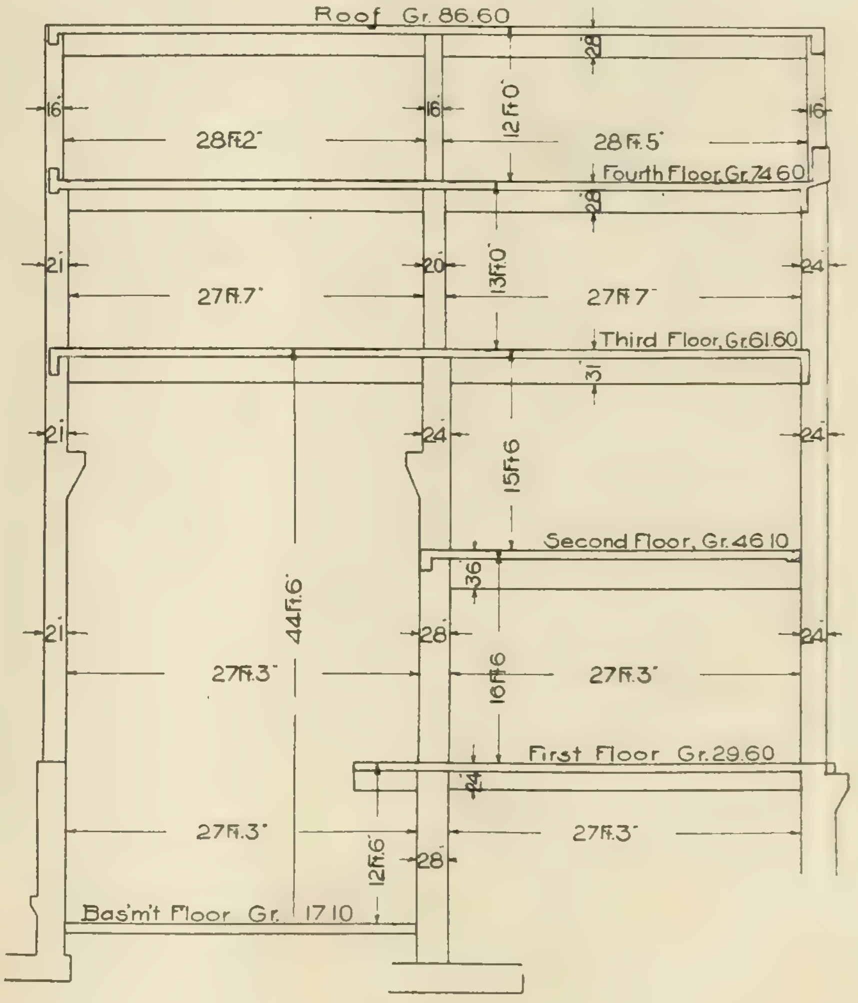
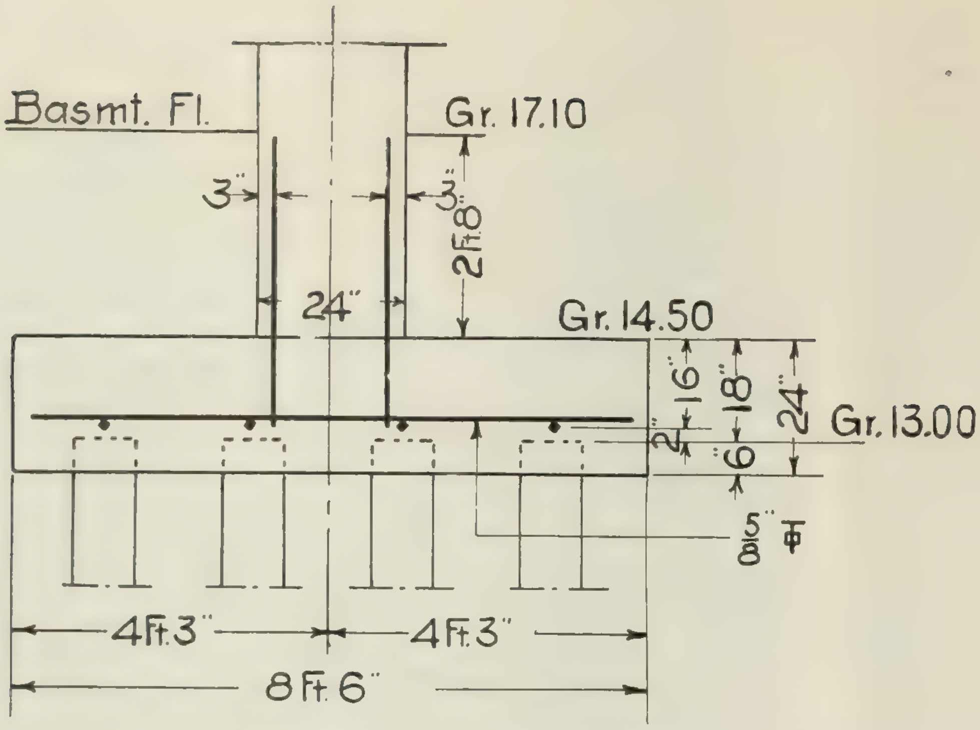


Fig. 8—Cross-Section, Building on Minor Court

Fig. 9—Cross-Section, Building on Major and West Secondary Courts



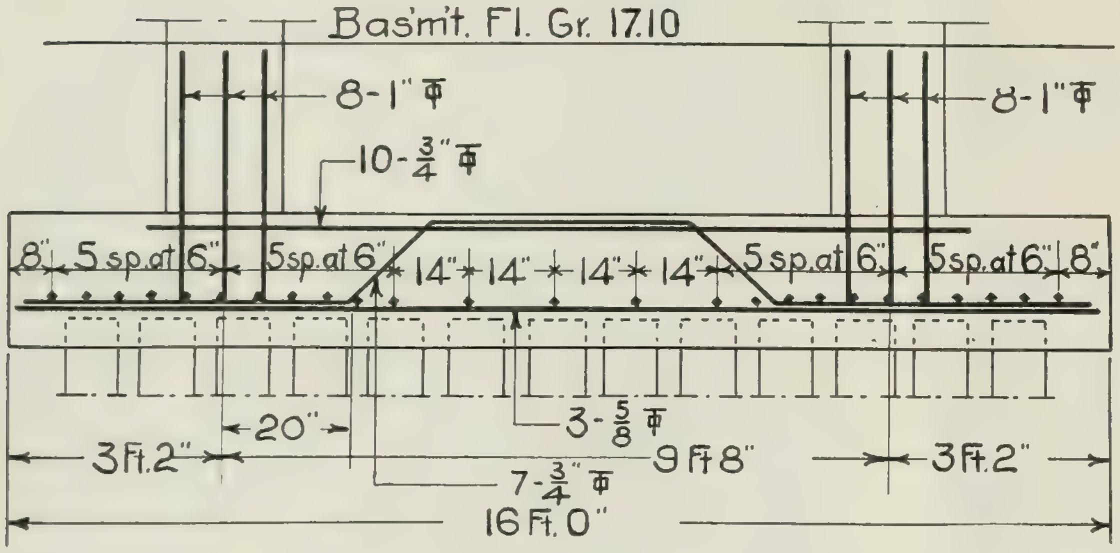


Fig. 10—Elevation—Interior Footing

Fig. 11—Section—Typical Bay—East Wall Footing

Bending Moment Coefficients

Ratio of short to long span	—Max. M_1—		—Max. M_2—		M_3		
	Dead load	Live load	Dead load	Live load	Dead load	—Live Load— Positive	Negative
0.3	.084	.085	—.090	—.101	—.077	.009	—.086
0.4	.087	.089	—.083	—.096	—.063	.015	—.078
0.5	.087	.092	—.082	—.095	—.049	.022	—.072

Case II—Panel with one intermediate beam; slab 7′ 9″.

Case III—Panel with no intermediate beam; slab 15′ 6″ with tile.

In Table I are summed up the relative costs for the three cases. It is evident that cost of forms is the important factor, completely upsetting the conclusions that would be drawn from the relative costs of the materials actually used in the slab.

BEAM REINFORCEMENT

Beams are all continuous and negative moments were provided for in the design. The location of bends in steel was always selected so as to leave as much steel as was required for both tension and compression stresses. As a rule, about 1/8 of the shear was considered to be carried by the bent bars in accordance with recent German tests. Typical beams and columns are shown in Figs. 6 and 7. Typical cross-sections of the buildings are shown in Figs. 8 and 9.

Unusually long beams of special design were used in the construction of the pavilions in Buildings 1, 2, 5 and 6, where it was desirable to have class rooms over 40′ x 40′ with no inside columns. Four beams running at right angles to each other, two in each direction, divided the floor into four nearly square panels. The beams were 18″ x 36″ and the reinforcement consisted of six 1-in. and six 7-in. bars at the center and five 1-in. and two 7/8-in. bars at the ends. All bars were square twisted steel. The pavilion roof beams are also unusually large because of the architectural treatment. In building 17 there is a 48-ft. beam 24″ x 60″, reinforced with 18 1-in. bars at the center and 1-in. bars at the end. In this case it was necessary to strengthen the support by haunches.

INTERIOR COLUMNS

All interior columns are square and reinforced with vertical steel only. Bands were placed 12″ o. c. to keep the steel in position during construction. The eccentricity of interior columns was neglected because the short beams were designed with sufficient steel to prevent bending the column.

WALL COLUMNS

In the design of wall columns account was taken of the bending moment produced by the rigidity of the connection between beam and column. The eccentricity in this case was computed carefully and enough steel provided to take care of it. To provide for the bending moment in the top story, however, it would have been necessary to use larger columns than the architectural treatment would permit. Therefore, to prevent a bending moment in the columns, it was decided to

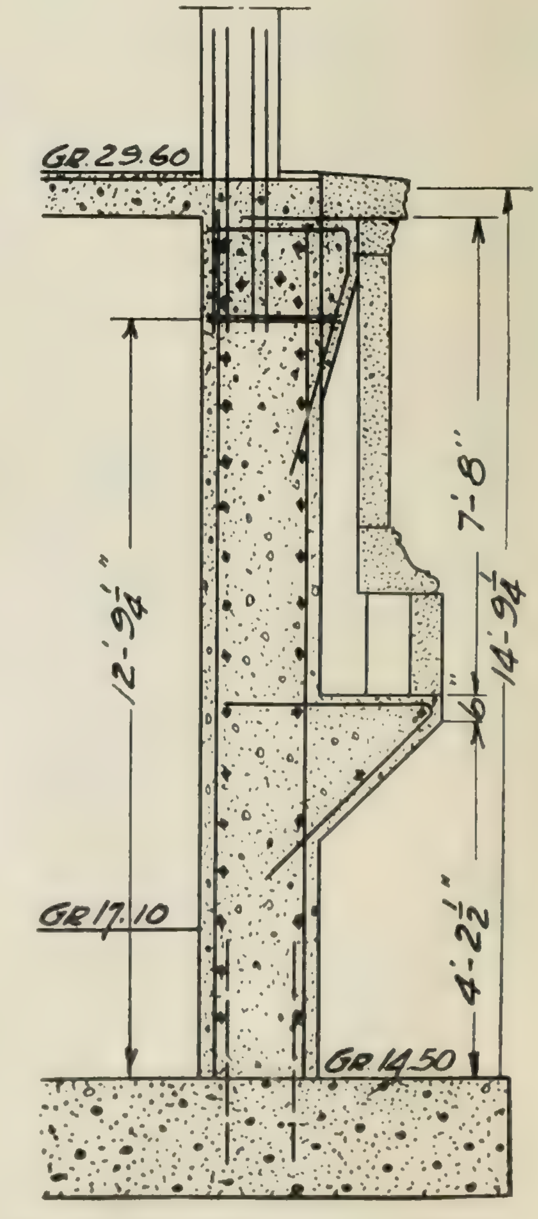


Fig. 12—Cross-Section of Basement Wall

make a joint between the columns and roof beams and not to carry the outside reinforcement through the beam. Columns were then designed for the superimposed load placed on the column with an eccentricity of 0.4 the width of the column.

SLABS

The floor slabs, which are continuous, were designed for a bending moment $\frac{wl^2}{12}$ at the support and the same moment in the center of the span. To prevent cracks in the building as far as possible, short bars were placed on the top over each girder whenever the main slab reinforced ran parallel to the girder, and, in fact, wherever there was danger of negative stresses.

WALLS

Retaining walls were cast monolithic with the wall columns except on the outside wall. In the minor and the major courts separate retaining walls were built about 3′ 9″ from the building line. Typical dimensions and reinforcement are shown in Figs. 6 and 7.

FOOTINGS

The design of footings varies in different parts of the structure. In certain buildings the interior footings are continuous; in others individual footings are used, and in still others two interior columns are placed on one footing. All outside footings are continuous. Footings rest on wood piles of spruce or oak, depending upon the character of the ground, as determined by thorough tests. Figs. 10, 11 and 12 give a general idea of the design and reinforcement of the footings.

FLOOR SURFACES

Special studies of floors were made and several experimental slabs were built in order to find the method of placing that would result in minimum dusting and a satisfactory bond with the slab. The scum which always rises on the surface of base concrete was removed by brushing the slab with a wire brush just as it began to harden. The tests showed that dusting is best prevented by using coarse sand containing scarcely any dust and mixed with broken stone ranging from ¼″ to ½″ in size and mixed in a stiff mortar 1:¾:1¼. As a result of laboratory tests, stiff neat cement brushed into the set concrete was selected as the best bonding material between the base concrete and the granolithic work.

ITEM	UNIT COST	CONCRETE SLAB SPAN 15′6″		CONC SLAB SPAN 7′9″ ONE INTERMED BEAM		HOLLOW TILE SPAN 15′6″		PAGE REFERENCE CONCRETE COSTS
	$	AMT	COST $	AMT	COST $	AMT	COST $	COSTS
CONCRETE PER PANEL (bf)								
SLAB CU. YD		10.7		6.1		6.6		
BEAM CU. YD		2 8		2.6		2.2		
GIRDER CU. YD		—		0.65		—		
TOTAL	5.82	13.5	78.50	9.35	55.00	8.8	51.22	
STEEL PER PANEL (bf)								
SLAB LB.		1080		435		607		
BEAM LB.		944		1620		944		
GIRDER LB.		—		690		—		
TOTAL	0.027	2024	55.60	2745	75.00	1551	41.88	
TILE PER PANEL (bf)								
SLAB PIECE	0.200					286	57.20	
TOTAL COST OF MATERIALS (bf)			134 10 bf		130.00 bf		150.30 bf	
FORM LUMBER (bf)								
SLAB – 1¼″ STOCK – FT. B.M		1772		1435		1772		617
BEAM 1½″ " FT. B.M.		496		680		429		619
GIRDER 1½″ " FT B.M				267		—		619
TOTAL FOR 4 FLOORS		2268		2382		2201		
TOTAL PER FLOOR PER PANEL	$ 30 M	567	1700	596	17.86	5.50	16.50	
FORM LABOR (bf)	CARPENTER LABOR 50¢ PER HOUR ORDINARY LABOR 25¢ PER HOUR							
SLAB (bf)								640
MAKE,		4.39		3.78		4.39		
PLACE AND REMOVE FIRST FLOOR		12.88		11.48		12.88		
SECOND FLOOR		9.88		8.57		9.88		
THIRD FLOOR		11.02		9 31		11.02		
FOURTH FLOOR.		11.02		9.31		11.02		
TOTAL COST 4 FLOORS		49.19		42 45		49.19		
COST PER PANEL PER FLOOR			12.30		10.61		12.30	
BEAMS (bf) MAKE,		3.00		2 10		2.70		639
PLACE AND REMOVE FIRST FLOOR		5.79		4.40		5 10		
SECOND FLOOR		5.20		3.90		4.60		
THIRD FLOOR		6.92		5.10		6.80		
FOURTH FLOOR		6.92		5.10		6.80		
TOTAL COST PER BEAM 4 FLOORS		27.83		20.60		26.00		
COST PER PANEL PER FLOOR			6.95		10.30		6.40	
GIRDERS (bf) MAKE,				2.30				641
PLACE AND REMOVE FIRST FLOOR				4.80				
SECOND FLOOR.				4.10				
THIRD FLOOR				6.20				
FOURTH FLOOR.				6.20				
TOTAL COST 4 FLOORS				23.60				
COST PER PANEL PER FLOOR					9.50+			
TOTAL COST FORMS (bf)			36.25 bf 170.35 bf		48.27 bf 178.27 bf		35.20 bf 185.50 bf	

+ MULTIPLY COST PER PANEL PER FLOOR BY 1.6 INSTEAD OF 2 TO ALLOW FOR SPANDREL BEAM

TABLE I—RELATIVE COST OF DIFFERENT SLAB DESIGNS

Note that cost of forms and not cost of materials used in beams and slab determines relative cost of the three alternate designs.

Forms assumed to be used four times and remade once for a change in size of columns. Costs are from *Concrete Costs,* by Taylor and Thompson according to page numbers given. Size of beam below slab 12″ x 19″. Size of girder below slab, 14″ x 19″.

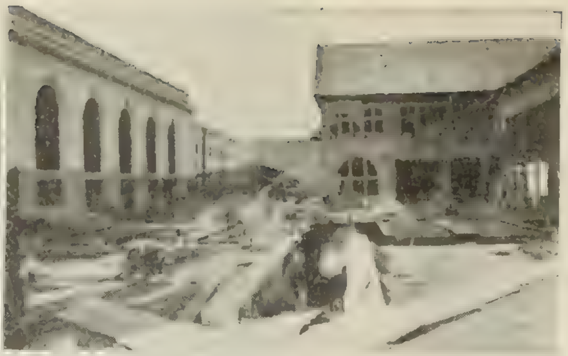
The architect is William W. Bosworth; the engineers and builders, Stone & Webster Engrg. Corpn., and the consulting engineers are Charles T. Main, on the footings; J. R. Worcester & Co., on the structural steel; Sanford E. Thompson, on the concrete superstructure; and Hollis French & Allen Hubbard, on the heating and ventilating system.

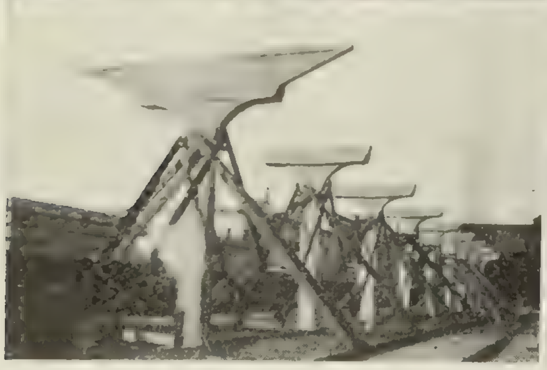
Stopping Leaks in Concrete Walls

Frank Noren, Carpenteria, Cal., contributes the following suggestion for stopping local leaks on concrete walls.

Clean out the hole or crack and cut it large enough to calk easily. Soak newspaper and sprinkle with dry cement 1/16″ thick on both sides. Crimple into a ball and plug the hole tightly. If the force of the water softens the mass too fast force in more dry cement and hold the mass tightly in place. It may be necessary to try several times, but the trick can usually be done.

Not many years ago if a progressive business man—about to erect a structure—heard the suggestion that he should build with reinforced concrete, he raised his eyebrows and said: "You will have to show me why I should build it of reinforced concrete." To-day this selfsame business man facing the selfsame problem, says to everyone who mentions a different method of construction: "You will have to show me why I should not build it of reinforced concrete." — *Knickerbocker Komments.*





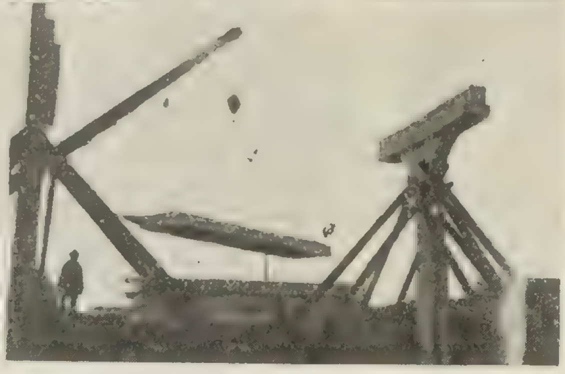


Fig. 1—General View, Showing Incline to Subway and Unit Columns in Background

Fig. 2—View of West End of Shed No. 1, Showing Nine Columns in Place Prior to Placing of Roof Slabs

Fig. 3—General View, Showing Old and New Stations and Incline to Subway

Fig. 4—Placing Roof Slabs

Unit-Built Concrete "Umbrella" Sheds, Los Angeles, California

By Rolf R. Newman[1]

As an example of separately molded structural concrete work the construction of a unique type of umbrella shed at the new Southern Pacific depot in Los Angeles is most interesting. These sheds form part of a system of subways, inclines and platforms for taking care of the arrival and departure of passengers. There are four of these sheds, each 740′ long and each divided into 37 bays of 20-ft. span. Fig. 2 shows the first nine columns erected at the west end of shed No. 1. Back of the row of columns in this view can be seen some of the roof slabs on flat cars just as they have been hauled over from the casting yard. Two roof slabs, meeting at the center, cover the span between alternate columns.

Each shed extends right and left from a central subway. The portion of this subway at present under construction is 33′ 6″ wide by 220′ long and is depressed about 15′ below the level of the tracks. From this subway access is had to the sheds above through eight inclines (four on either side) each 7′ wide by 65′ 6″ long—the subway and inclines being entirely of monolithic concrete (Figs. 1 and 3). The roofing of the inclines requires 32 special "unit-built" semi-circular arches, as shown in Figs. 6 and 15, the latter showing one of the arches being placed. The method of placing by means of the locomotive crane is shown particularly well and in the lower left hand corner of the same view is seen a portion of the concrete wall of the incline.

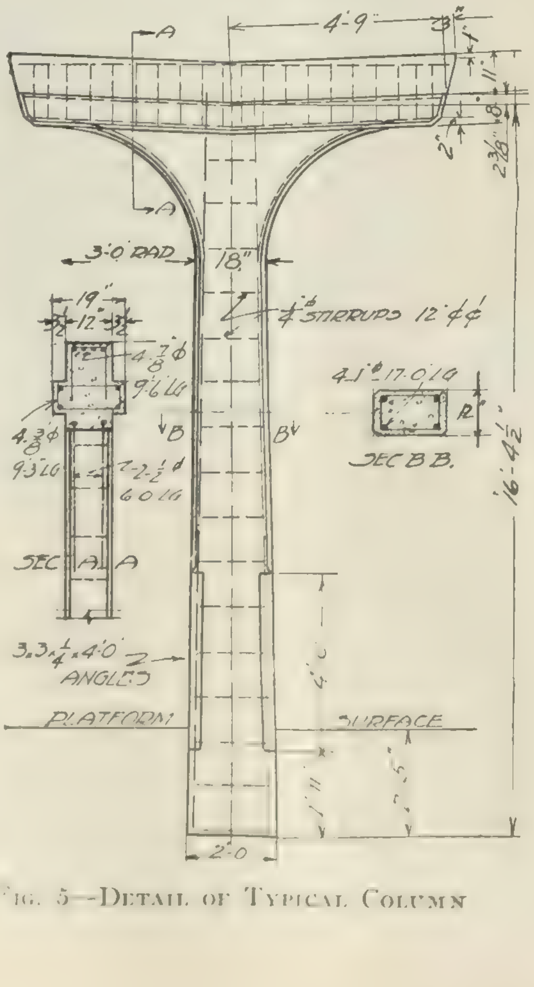


Fig. 5—Detail of Typical Column

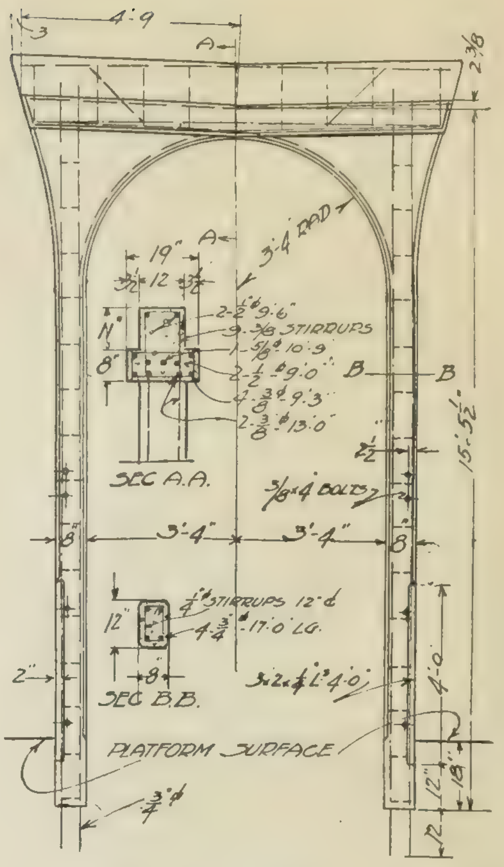


Fig. 6—Detail of Arch Column Over Subway

DESIGN

A splendid idea of the necessary amount of steel reinforcement and the thoroughness of the design may be had by a glance at drawings Figs. 5, 6 and 8. The largest single column unit weighs 8,595 lbs. and the actual amount of reinforcement in this one unit (Fig. 2) is as follows:

4–1″ straight square bars 17′ 0″ long
4–⅞″ straight round rods 9′ 6″ long
2–½″ curved square bars 11′ 0″ long
2–½″ curved square bars 6′ 0″ long
2–½″ square stirrups 7′ 0″ long
2–⅜″ round stirrups 17′ 9″ long
3–⅜″ round stirrups 9′ 3″ long
20–⅜″ square stirrups 7′ 0″ long
8–¼″ square stirrups 4′ 0″ long
2–¼″ square stirrups 5′ 0″ long
2–¼″ square stirrups 4′ 3″ long
2–¼″ square stirrups 3′ 6″ long
2–¼″ square stirrups 2′ 9″ long
4–¾″ round anchor ties for slabs 2′ 6″ long
5–¼″ square column hoops 5′ 0″ long
5–¼″ square column hoops 5′ 8″ long
2–1″ L. H. round rods 8′ 0″ long

The roof slab units (Fig. 7) are heavier, weighing 11,100 lbs. each; their volume is 74 cu. ft. Stress sheets (Tables 1 and 2) show the calculations for typical columns and slabs. An interesting detail of the roof slabs is that they are not only designed to turn rain water back from the edge toward the center of the shed roofs, but each slab is cast thicker at one end than at the other, so that when two thick ends come together they form a ridge, turning water lengthwise of the shed to valleys at the meeting of two thin ends

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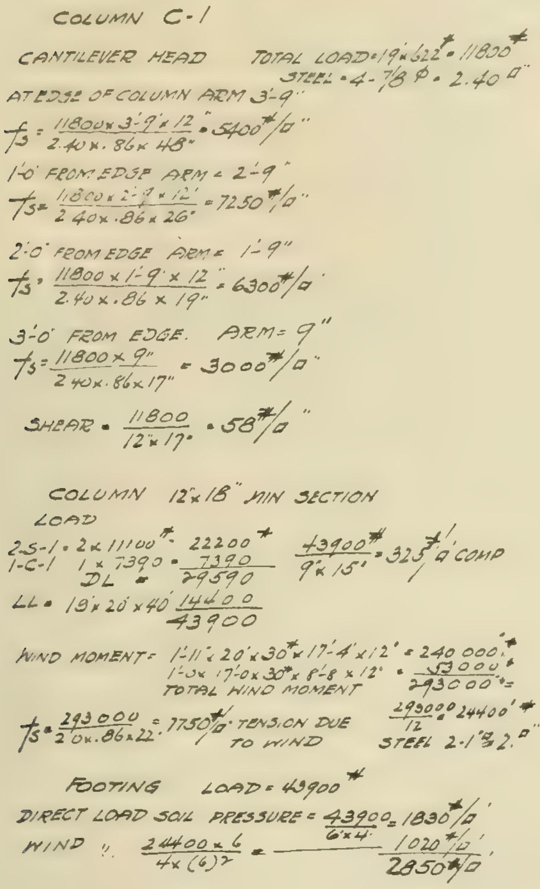
[1] Civil Engr., Riverside, Cal.

DESIGN DATA SHEETS FOR UMBRELLA SHED UNIT MEMBERS

TABLE 1



COLUMN C-1

CANTILEVER HEAD TOTAL LOAD = 19×622# = 11800#
STEEL = 4-7/8 φ = 2.40 □"

AT EDGE OF COLUMN ARM 3'-9"

$f_s = \frac{11800 \times 3'\text{-}9" \times 12"}{2.40 \times .86 \times 48"} = 5400\#/\square"$

1'-0" FROM EDGE ARM = 2'-9"

$f_s = \frac{11800 \times 2'\text{-}9" \times 12"}{2.40 \times .86 \times 26"} = 7250\#/\square"$

2'-0" FROM EDGE ARM = 1'-9"

$f_s = \frac{11800 \times 1'\text{-}9" \times 12"}{2.40 \times .86 \times 19"} = 6300\#/\square"$

3'-0" FROM EDGE. ARM = 9"

$f_s = \frac{11800 \times 9"}{2.40 \times .86 \times 17"} = 3000\#/\square"$

$\text{SHEAR} = \frac{11800}{12" \times 17"} = 58\#/\square"$

COLUMN 12"×18" MIN SECTION
LOAD
2-S-1 = 2×11100# = 22200#
1-C-1 1×7390 = 7390
DL = 29590
LL = 19'×20'×40' 14400
43900

$\frac{43900\#}{9" \times 15"} = 325\#/\square"$ COMP

WIND MOMENT = 1'-11"×20'×30#×17'-4"×12" = 240000"#
1'-0×17'-0×30#×8'-8×12" = 53000"#
TOTAL WIND MOMENT 293000"#

$f_s = \frac{293000}{2.0 \times .86 \times 22"} = 7750\#/\square"$ TENSION DUE TO WIND

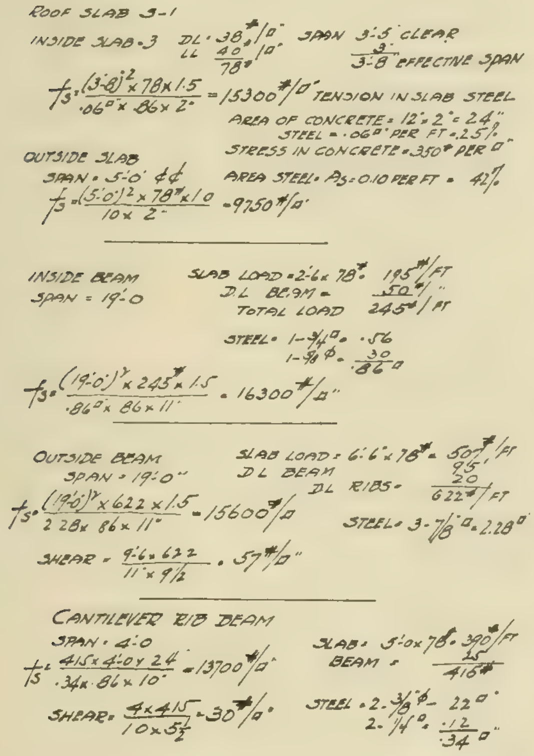
$\frac{293000}{12} = 24400'\#$
STEEL 2-1"□ 2.□"

FOOTING LOAD = 43900#

DIRECT LOAD SOIL PRESSURE = $\frac{43900}{6' \times 4'} = 1830\#/\square'$

WIND " $\frac{24400 \times 6}{4 \times (6)^2} =$ 1020#/□'
2850#/□'

TABLE 2



ROOF SLAB S-1

INSIDE SLAB-3 DL = 38#/□' SPAN 3'-5" CLEAR
LL 40#/□' 3"
78# 3'-8" EFFECTIVE SPAN

$f_s = \frac{(3'\text{-}8")^2 \times 78 \times 1.5}{.06\square" \times .86 \times 2"} = 15300\#/\square"$ TENSION IN SLAB STEEL

AREA OF CONCRETE = 12"×2" = 24□"
STEEL = .06□" PER FT = .25%
STRESS IN CONCRETE = 350# PER □"

OUTSIDE SLAB
SPAN = 5'-0" ¢¢
AREA STEEL = As = 0.10 PER FT = .42%

$f_s = \frac{(5'\text{-}0")^2 \times 78\# \times 1.0}{.10 \times 2"} = 9750\#/\square"$

INSIDE BEAM
SPAN = 19'-0
SLAB LOAD = 2'-6×78# = 195#/FT
D.L BEAM = 50#/FT
TOTAL LOAD 245#/FT

STEEL = 1-3/4"□ = .56
1-5/8"φ = .30
.86□"

$f_s = \frac{(19'\text{-}0")^2 \times 245\# \times 1.5}{.86\square" \times .86 \times 11"} = 16300\#/\square"$

OUTSIDE BEAM
SPAN = 19'-0"
SLAB LOAD = 6'-6"×78# = 507#/FT
DL BEAM 95
DL RIBS = 20
622#/FT

$f_s = \frac{(19'\text{-}0")^2 \times 622 \times 1.5}{2.28 \times .86 \times 11"} = 15600\#/\square"$

STEEL = 3-7/8"□ = 2.28□"

$\text{SHEAR} = \frac{9'\text{-}6 \times 622}{11" \times 9\frac{1}{2}} = 57\#/\square"$

CANTILEVER RIB BEAM
SPAN = 4'-0

$f_s = \frac{415 \times 4'\text{-}0 \times 24}{.34 \times .86 \times 10"} = 13700\#/\square"$

SLAB = 5'-0×78# = 390#/FT
BEAM = 25
415#

$\text{SHEAR} = \frac{4 \times 415}{10 \times 5\frac{1}{2}} = 30\#/\square"$

STEEL = 2-3/8"φ = .22□"
2-1/4"□ = .12
.34□"

—with downspouts at every other column.

CONSTRUCTION METHODS

The casting yard is located in a portion of the Southern Pacific yards about half a mile from the depot. A locomotive crane used in the erection of the units is also used at the casting yard in handling material, forms, etc., and in loading the units upon cars for transportation to the job. Figs. 9, 10, 12 and 13 are views in the casting yard and illustrate quite fully the methods in use. Fig. 12, for instance, shows a column form with reinforcement in place ready to fill. Fig. 13 is a general view of the portion of the yard devoted to column casting. Fig. 10 shows the portion of the yard in which the slabs are cast. It may be noticed that each slab form rests upon railroad rails which have been brought to a level previous to placing the form. The proximity of the tracks for the convenient use of the locomotive crane is noticeable in both general views of the yard. Fig. 9 is a near view of one of the slab forms, showing prominently one of the 11-in. rib portions of the form. These rib depressions of the slab forms are lined with thin metal to produce a smoother surface and to strip more easily; both the metal and the wooden portions of the forms are coated with paraffin oil before casting. The paraffin form oil is purchased in 50-gal. bbls. and is found very economical. The mixer in use at the casting yard is a 16-ft. Cube mixer[2] and each batch is poured out

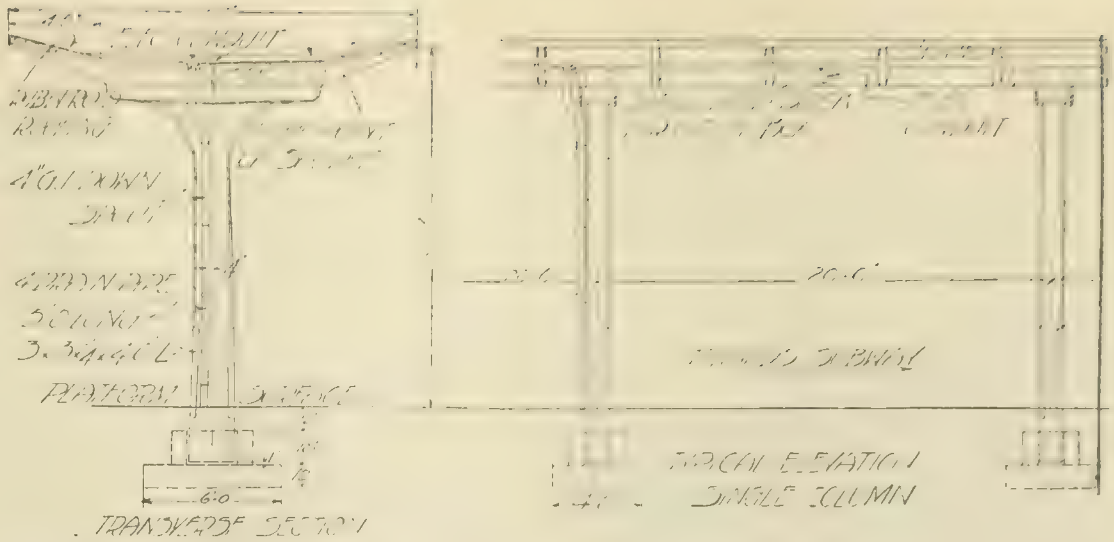


Fig. 7—Column and Slab Details

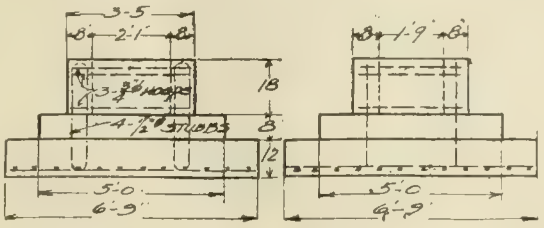


Fig. 8—Footing Detail

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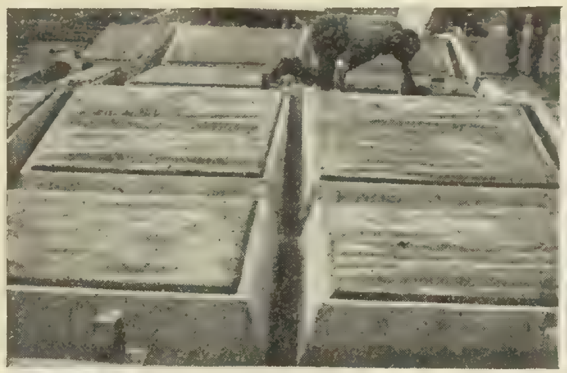
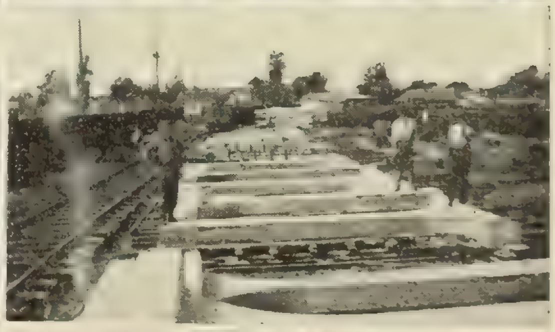
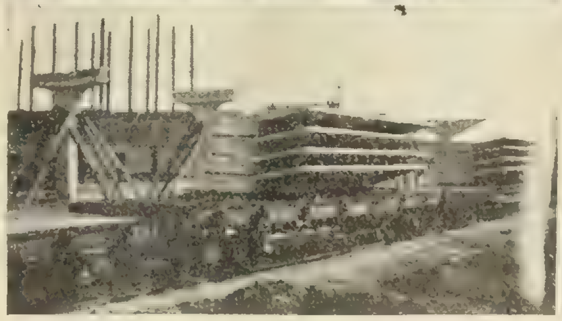
[2] Municipal Engrg. and Contracting Co., Milwaukee







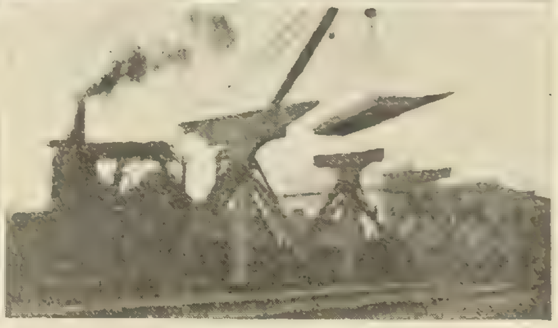


Fig. 9—Roof Slab Forms

Fig. 10—Casting Roof Slabs

Fig. 11—Roof Slabs Loaded on Flat Cars. Columns in Place in Background

Fig. 12—Column Forms

Fig. 13—Side Forms Stripped from Columns

Fig. 14—Locomotive Crane Placing Roof Slab

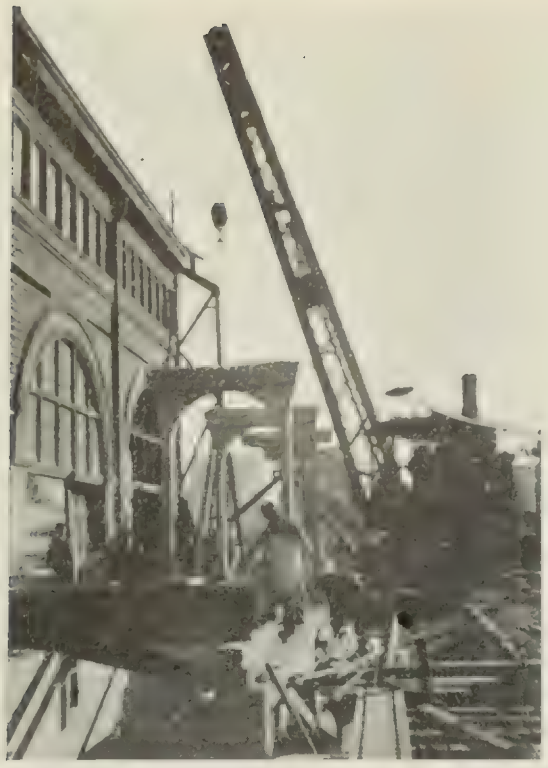


Fig. 15—Crane Handling "Unit-Bilt" Arch. Incline to Subway in Left Fore-ground

into a large moveable hopper, which is picked up by the crane and carried to the slab or column form to be filled. The side forms are made separate from the bottom forms and can, of course, be removed and prepared to use over again sooner than can the bottom forms. For this reason 30 slab bottom forms have been provided but only 10 pairs of slab sides are necessary. The sides are taken off after 24 hrs., but the units are not removed and the bottom forms freed in less than 7 das.

Fig. 3 looks directly down the incline from the west portion of Shed No. 1 (the row of columns shown in Fig. 2 being directly behind). The subway at the foot of the incline leads to the new depot, which is seen at the left of the view. At the right is the old depot in process of demolition but through which traffic has had to be maintained during the changing over from old to new.

The writer is indebted to Shirley Houghton and to Supt. Frank Simonds of the Van San-Houghton Co.[3] for much of the material in this article.

* * *

The concrete contractors of the Memphis (Tenn.) Builders' Exchange have formed an organization to maintain "fair and honest competition." Cost records will be kept which are to be for common use and an effort made to discourage incompetent and irresponsible "curb contractors."

A Cooling Room for Farm Use

A cooling room for farm use, as built by A. Farragut, contractor, Pascagoula, Miss., is proving of great benefit to the farmers in his locality. It is a timely suggestion to the farm contractor. The illustrations show plainly the size and the design of the building, which can be varied to suit requirements.

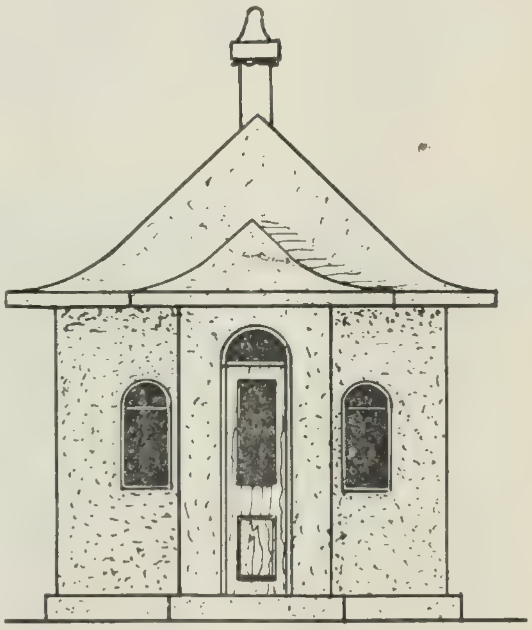
The secret of the building's success depends on a double concrete wall, which assures a very high degree of insulation. This air space should be continuous and be perfectly sealed.

In the construction of this building a hollow wall machine[1] was used, building the wall simply and economically. A double wall of block or even metal lath, plastered, would give similar results. A simple cornice and roof form was placed and the roof cast as shown, with provision for attaching furring and metal lath to give air space in the roof.

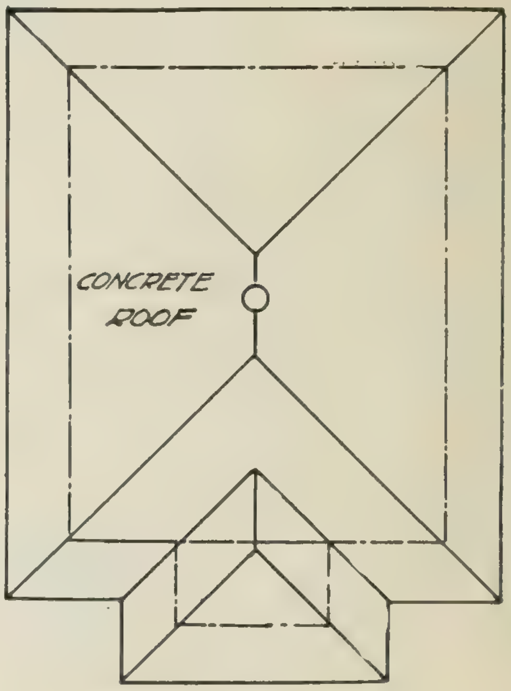
The cooling is effected by leading a stream of cold spring water through the trough cast with the floor and suspending a blanket with its edge touching the water, as shown by the illustration. The cold water is drawn up by capillary attraction and evaporated, reducing the temperature.

A ventilator with a damper is provided as shown to dispose of excessive dampness.

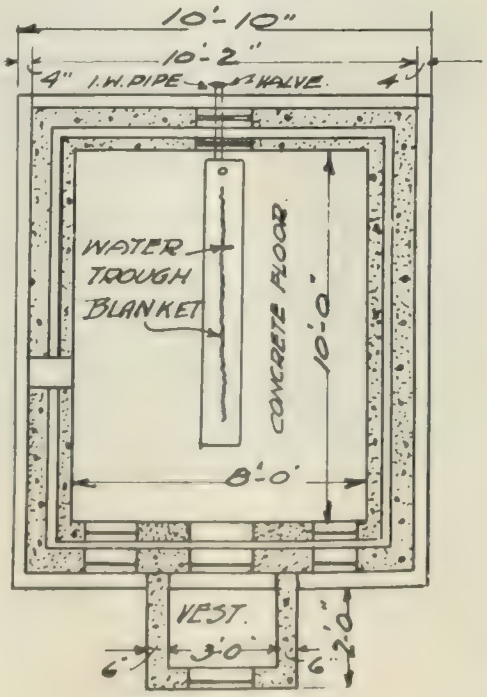
In early spring, when not needed for cooling, the building is an ideal incubator house as it holds a constant temperature.



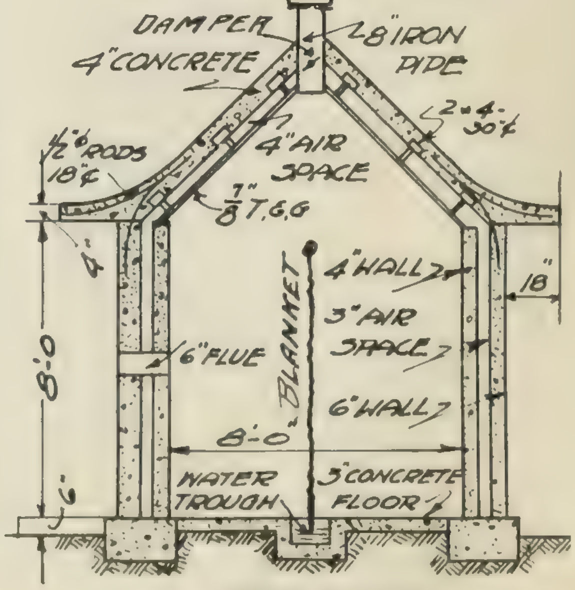
FRONT ELEVATION



ROOF PLAN



FLOOR PLAN



CROSS SECTION

* * *

After several conferences held recently in N. Y. C. by the large cement corporations, it is reported that the price-cutting war which has been going on for the last few months in the East, has been called off, and price of cement per bbl. alongside dock has been raised to $1.32.

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[1] Van Guilder Hollow Wall Co., Rochester, N. Y.

[3] Engrs. and Contrs., San Francisco, Cal., Western Rep. Unit Constr. Co., St. Louis, Mo.

Field Methods in Concrete Construction — Wall Forms: Design and Construction

By Jerome Cochran, C. E[1]

The series of articles on field methods in concrete construction, of which this is the sixth, has been planned in opposition to the general assumption on the part of writers that standards or methods of construction have been established long ago and have become common knowledge. The first article, on "Selection of Concrete Materials," appeared in this magazine for Jan., 1915; the second article, on "Proportioning and Mixing Concrete," appeared in Feb., 1915; the third article, on "Design and Construction of Forms in General," appeared in Mar., 1915; the fourth article, on "Column Forms," appeared in Apr., 1915; and the fifth article, on "Beam and Slab Forms," appeared in June, 1915. The following article relates to the fabrication and the erection of wall forms, and is in reality a continuation of the Mar., 1915, article, to which the reader is referred for illustrations of properly and improperly braced wall forms. For this reason no illustrations will be given in the present article.

INTRODUCTION

For walls it is necessary to make a form for each side and to hold the forms together by bolts or strong wires so spaced as to prevent any distortion. Wall forms may also be held apart with separators, which can be easily removed as the work progresses, or which may be incorporated in the concrete without injury to it.

In general it may be said that there are two modes of procedure for walls of any magnitude. First, on large buildings, walls may be carried up uniformly around the work in comparatively shallow horizontal layers. Second, complete forms the full height of the wall may be built in limited sections and they are poured full at one time.

The first method gives horizontal joints between different sections of concrete, the second gives vertical or irregular joints. The first method means more runways but the centering is usually much lighter because the pressure of concrete due to a thin layer is inconsiderable when compared to that due to the head in a deep form.

The construction of wall forms, while not involving the complex carpenter work demanded by floors with beams and girders as described in Concrete for June, 1915, does require considerable care in providing sufficient bracing to maintain the forms plumb and true to line.

ECONOMY OF WALL CONSTRUCTION

Any economy effected in the design of wall forms, so as to enable their re-use without waste, is sure to tell favorably in the cost of the work. With a little ingenuity and forethought, this work can almost always be arranged so that repeated use is made of each piece of lumber. This might at first appear to be a very simple matter to accomplish, but, on a job of any size, with labor and lumber at high prices, the question of the best method of construction presents itself in a different light.

Among the factors that play an important part in the economy of wall construction may be mentioned the kind, thickness and width of lumber; the method of making forms; kind, number and method of placing braces or ties; method of erecting, removing and transporting forms.

A rough and expensive method of constructing wall forms consists in nailing all the joints securely. Such forms cannot usually be removed without breaking the lumber to pieces and destroying some of the concrete.

FABRICATION OF WALL FORM UNITS

For convenience in handling and removal without injury to the completed work, wall forms are usually made and erected in panels or sections, which, after the concrete has set, may be taken down in one piece or unit and be set up again, thus also facilitating the placing and the removal of the forms. The number, arrangement and size of the units, which can readily be assembled, taken down and reassembled, are determined by the shape and size of the wall and the means adopted for handling the forms. Such forms are commonly employed in building construction for walls more than one story high. They should always be employed above one story, to save staging timber.

Battered edges of panel or sectional forms or planks warped so as to open up a joint, may be filled or made straight by means of a strip of wood, oakum, putty or clay. Where it is evident that these joints will provide an excessive roughness, or unsightly board marks, in the exposed concrete, the edges of the forms should be removed and replaced or otherwise improved and repaired before concreting. Care must be taken not to batter the edges of such forms when handling them in sections.

The lagging or planks used in wall forms should be surfaced, of uniform thickness and suitable width, and of selected material, and the edges surfaced so as to form tight joints when put in place. The lagging may be tongue-and-groove or bevel-edged, as desired. It should invariably be fastened to the studding or vertical uprights in perfectly horizontal lines. The ends of the lagging should be neatly butted against each other, and the inner surface of the form should be as nearly as possibly perfectly smooth, without crevices or offsets between the sides or ends of adjacent planks.

THICKNESS OF LAGGING

Wall forms vary in thickness from $\frac{7}{8}''$ to varying greater thicknesses, but under no conditions should exterior walls be cast in molds of varying thickness, regardless of what finish is adopted. Such walls will generally show a difference in color even when a $\frac{3}{4}$-in. plaster coating is applied and allowed to dry out. Wall forms are often made up with plank not less than 1″ thick for small panels, which are light and easy to handle. However, for ordinary walls, $1\frac{1}{2}$-in. lumber with 3-in. x 4-in. or 3-in. x 6-in. vertical upright on each side, spaced not over 3′ o. c., is usually used, although for heavy construction, where derricks are used, 2-in. stuff is preferable. Thin planks reduce the weight of the units or panels to be handled as well as the amount of form lumber required, and are generally amply strong, provided they are properly braced. Thick planks, however, will hold their shape better and last longer, and should be used for forms which are to be used a number of times, as thin material is easily broken.

If the wall forms are to be used once only, they are usually made of 1-in. lumber planed on one side and double-edged, one edge being slightly beveled and placed against the straight edge of the next plank and driven to form a tight joint with an even surface. If the forms are to be used several times, they are made of either 1½-in. or 2-in. dressed planks, because they usually withstand the successive operations of demolishing and erecting much better than the lighter material, especially when not made up in units.

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[1] Cons. Engr., Houston, Tex.

The forms may also be made of tongue-and-groove boards, as described and illustrated in the June, 1915, article for slab forms, being fastened together with battens or cleats.

SPACING OF STUDS

Studs should be of sufficient size and so spaced as to prevent the lagging from springing between studs. As a rule, the spacing of studs for ⅞-in. planks is 2′; for 1⅛-in. planks, 3′ 6″, and for 1¾-in. planks, 4′ 6″. The studding for all wall forms should be dressed or sawed to an even thickness in order that the alignment may be perfect.

INTERIOR SUPPORT OF WALL FORMS

Forms when used on both sides of a narrow wall may be held together by bolts, wires or special devices, so as to prevent the forms from bulging and at the same time keep them the proper distance apart. Bracing for wall forms is poor practice if the walls can be reached from both sides to use wire, straps or bolts.

Wooden struts or concrete struts may be used for supporting wall forms from the interior while filling. These struts or spacers should always be placed where the sheathing or lagging is supported by a stud or upright, spaced so as to prevent distortion, and the wire should loop opposite studs and be twisted with a stick, as a turn-buckle, until the studs are the proper distance apart.

Wall ties, whether bolts, wire or steel, should be put through the forms at right angles, or square with the wall. The centering will be "skewed" if this is not watched.

EXTERIOR BRACING OF WALL FORMS

The wall forms, in addition to the interior bracing, should be securely braced on the outside to withstand the loads that come upon them and to preserve their alignment.

Inclined props or braces reaching from the ground to the upright studs are used for bracing retaining walls of moderate height. The ordinary braced staging used by masons and carpenters or a gallows frame arrangement is usually used for building walls of some height.

The posts and braces should be of sufficient strength to make a practically unyielding support to the lagging. The braces (generally 2-in. x 4-in. scantling) should be designed to resist all tendency to slide, and may be useless if put in without thought. The upright studs should be braced horizontally by running a horizontal stringer piece the full length of the wall and bracing it to some substantial support to keep the wall in line. Wire ropes should not be used for braces, as the stretch in these may be disastrous to the wall.

Braces should be firmly fixed at the foot and the top, and as many braces and supports used as may be necessary to prevent deflection from the working of the concrete. Diagonal braces for forms for foundations, retaining walls and ordinary construction are usually held in position by posts driven into the ground. The usual way is to drive the posts on a slant, but experience has shown that vertical posts are the stiffer, especially when the ground is poor. The posts should also be driven deep in order that they may obtain sufficient anchorage, as the top soil is seldom able to carry much of a load. Earth is a poor material to depend upon for holding wall forms rigid, and failures of such forms are frequently caused by the giving way of the posts due to the yielding of earth.

Put no trust in nails, but use positive shoulder action at all points, with nailing blocks or otherwise. Never brace a shore back into the ground without a base block under it. Proper and improper methods of bracing wall forms are illustrated and described in the third of this series of articles, published in this magazine for Mar., 1915.

Care should be taken to see that wall forms are prevented from lifting during the process of filling them. Forms with considerable batter may be anchored by a hook made of reinforcing steel, embedded in the foundation and fastened with No. 8 wire. The upward or side movement of forms in trench work may be provided for by bracing the forms in the sides of the trench.

USE OF WIRE TIES AND SPACERS

Wire ties may be used to secure wall forms against pulling apart, being wound around opposite studs and then twisted inside of the forms with a short bar or piece of wood until the studs are the proper distance apart. Before the wire is drawn up, a wooden spacer, strut or spreader of length equal to the required width of the wall is placed beside the wire, where it is left until the concrete reaches that height. Spacers should always be placed where the lagging is supported by a stud, and the wire should loop the stud or upright. The use of spacers unattached to the wire ties is probably the best and cheapest method of holding wall forms apart.

When the concrete has been placed to the level of the spacer or strut, the latter can be removed and the weight of the concrete will hold the forms apart. Wooden struts must be removed from the forms as soon as the concreting reaches them, while concrete struts may be left in if so desired.

On removal of the forms the projecting ends of all wire ties should be cut off or trimmed very close to the concrete surface, the edges stove in with a punch, and the surface smoothed over. This is done to keep rust spots from showing on the face of the wall, which will ultimately discolor it. Care must be taken to see that there are no wire ends left on the face of the concrete.

No. 8 wire will generally be found sufficiently strong for tying wall forms. Small wire should not be used where the forms will be subjected to much pressure of the wet concrete; the wire will cut into the wood and allow the forms to spread. Therefore, to protect a stud put a piece of scrap lumber under the wire. In twisting up (using No. 9 annealed) do not twist too tightly, or the wire will be burned and killed.

Although wall forms held by wire are much more secure than those which are merely braced, yet they possess the following objectionable features:

(1) The forms are likely to bulge, owing to the wire giving as the concrete is tamped. No practical way of taking up this give has yet been devised, although many attempts have been made.

(2) There is a temptation for workmen to knock the wooden spacers or struts out and leave them embedded in the wall, or bury them as they stand.

(3) The wire ties are not drawn and held rigidly in place during the filling of the forms.

(4) The ends of the wires are often left exposed when the forms have been removed.

BOLT TIES AND SPACERS

Wall forms may be held in place by means of bolts so made that the outer 3″ of the bolts can be removed after the forms are taken down, and the remaining holes filled with 1:2 or 1:3 mortar. This may be accomplished by sleeve-nut connections which will permit the removal of the projecting ends of bolts or rods, etc., leaving only small holes in the concrete, which can be stopped with mortar. Rods should be cut from 2″ to 4″ shorter than the space between the forms, and threaded, with a pump-rod coupling placed on the threaded ends. The bolt is finished by means of studs threaded at both ends, which may be screwed out of the concrete when the forms are struck and used again.

Bolts should be tightened against spacers or struts set between the two sides of the forms inside. They should preferably be enveloped inside the forms with sleeves, or thoroughly coated with heavy grease or other means taken to prevent adhesion of concrete to the bolt, as it is usually desirable to remove the entire bolt; otherwise the bolt will stick and can be drawn out only by wrenching and injuring the concrete. Bolts must be straight or it may be impossible to remove them. They are also likely to break the concrete in their removal, if they are not absolutely straight.

Washers should be used under all bolt-heads and nuts, and before proceeding with the concrete work forms should be brought true to line and grade, and all bolts should be taut. Trimming up bolts with a monkey wrench is low work. Use a ratchet wrench or hand-nuts.

Bolts through wall forms should not be within 9″ of a finished concrete edge if it is possible to place them elsewhere. Under no condition should they come closer than 4″ to a projecting corner or other detail, or the concrete may be spalled off in pulling them.

REMOVAL OF TIE-RODS

Usually it is desirable to remove the entire bolt or rod used to support thin wall forms. This may be done by coating the bolt with grease or wrapping it with stiff paper or oiled paper before the concrete is placed. The use of the latter makes the removal of the bolts more certain than with ordinary paper. The bolt may also pass through a tin tube or piece of pipe, which will act as a spacer for the forms as well as a sleeve for the bolt. Pasteboard tubes will usually be found efficient and much easier to place and trim than wrought-iron pipe.

When specified that tie-rods are to be left in the concrete wall, they may be provided with sleeve-nuts near the end; when unscrewed, these will leave the end of the rod within the wall not less than 2″ from the face.

A new type of concrete form tie recently put on the market consists of a pair of tapered stub bolts tapped on the small end to receive the threaded ends of the tie-rod, which may be of any length and may be cut and threaded on the job. A common laborer with a pipe wrench can place and secure or remove them. These ties save time, labor and lumber and leave no rough, unsightly holes nor studs nor ends in the face of the wall. The holes left by the stub bolts may be filled with 1:2 or 1:3 mortar after the forms are removed; or the holes may be filled with cement paste mixed with some waterproofing compound.

Another type of tie consists of two short bolts, connected to wire loops in the body of the wall. The wire loops remain in the wall, while the shallow holes, left on each side when the bolts are removed, are filled with cement mortar to preserve its sightliness.

The method of using oil or grease to facilitate the removal of tie-rods is objectionable where an impervious seal is required, as the oil prevents a water-tight bond between the mortar plug and the body of the wall.

CONCRETE WALL SPACERS OR STRUTS

Concrete spacers or struts, made in advance of being used and allowed to set hard, may be substituted for those of wood. They need not be closer than 3′ in each direction, provided the wall is not too high, and should be placed in the same manner as those of wood. They should be broken with a tamper when the concrete is placed to the proper level; or, if they have been cast with a water stop, they may remain in the wall.

Concrete spacers, composed of the same quality of concrete as the rest of the wall, may be used where the appearance of the exterior surface of the wall is of no great importance. They generally present a bad appearance in the finished wall if allowed to remain. Care should be taken to prevent a void immediately under the spreader or a water channel along the side of the spreader.

A good form of spreader consists of a concrete block about 2″ x 2″ or 3″ x 3″ by thickness of the wall, with a longitudinal hole 1/8″ larger than the bolt to be used. When the forms are removed the holes are filled on each side with cement mortar. The concrete struts may also be used as ordinary spreading strips, without having holes through them.

OPENING AT BOTTOM OF WALL FORMS

The bottom board in wall forms should be placed last, so as to adjust the wall reinforcement, if any, and to remove sawdust, shavings, chips and other materials that collect in the walls. Where this is not practicable, loose hand-hole caps or small removable panels should be provided at the base of wall forms, being tacked to the wall side so that they will be ready to put back in place after the wall is cleaned out and before the wall is poured. All openings in forms must be effectually stopped to prevent the escape of water so far as practicable, and the contractor should not be allowed to close these openings until all is in readiness for pouring the wall.

ALIGNMENT OF WALL FORMS

Wall forms should be erected as far as possible in exact alignment, both vertically and horizontally. A wall which is out of line or plumb not only looks bad but may be required by the engineer to be removed and corrected. The expense for one such correction will be many times that which would have been involved by proper care in the first place. The writer has seen some very excellent concrete work done in different parts of the country where many of the concrete walls were as much as 2″ or 3″ out of plumb. Little or no confidence should be placed in the ability of the average carpenter to carry walls vertically with a level. The building of plumb vertical walls can only be obtained when everybody on the work looks out for them. Plumbing wall forms is high-class carpenter work and should be done by a few careful or competent carpenters, and the rank and file in the form gang should be required to keep the lines fixed.

Careful check should be kept on the alignment of edges, corners and sides of movable panel forms used in wall construction; they require special skill and care to keep in line and should be carefully preserved by frequent tying and bracing of the forms and by the use of heavy stringers or rangers. Keeping of wall forms plumb is the most difficult thing which devolves upon the contractor.

Workmen may err on the side of poor alignment or more careful alignment than the wall requires. As a general rule is suggested the allowance of "3/8″ departure from established lines on finished work and 2″ on unfinished work." The latter may be increased indefinitely, depending on the size and nature of the work, but as a general rule the forms should be within 2″ of established lines.

FOUNDATION WALLS

Forms should be constructed for foundation walls in case the earth will not stand plumb in the excavation. Except in sand and gravel, no side pieces are required for footings, as all other soils will stand vertically for a depth of from 8″ to 24″; hence, all that is necessary is to dig the trench the exact width and depth required for the footings.

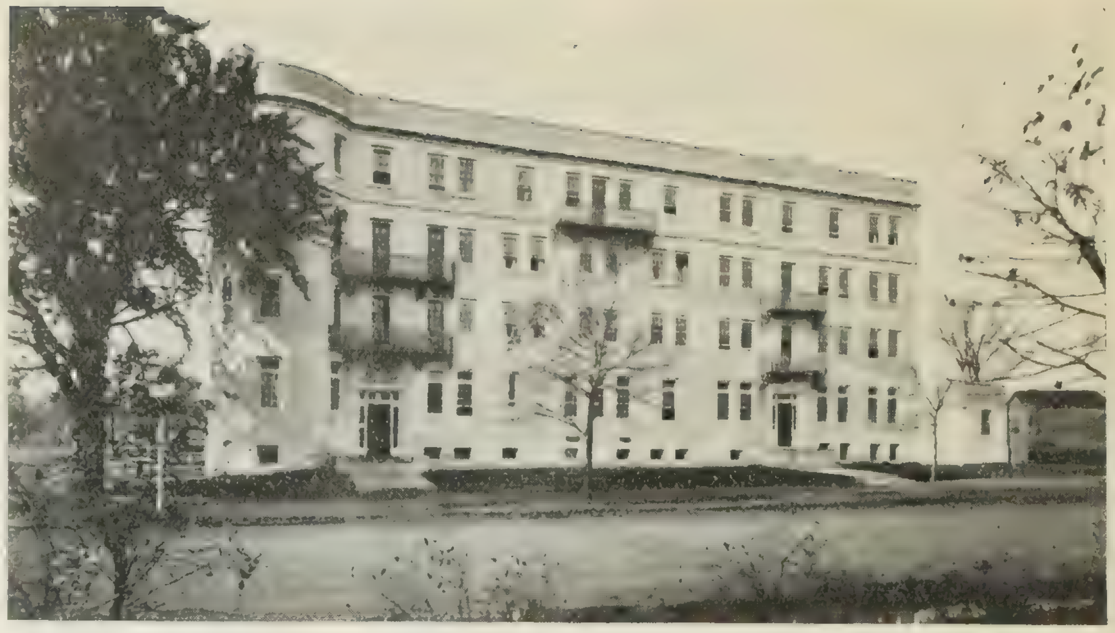

Fig. 1—General View Lucy Wheelock School, Cast Stone Trim, Boston

Forms for step footings may be made by using a form for one layer at a time. The form should be capable of being taken apart easily in order to remove it from around the concrete. This method is for layers 12″ thick and over.

For a battered face footing of shallow depth compared with its size, a form may be constructed of the size and depth of the outer square faces. Then fit perhaps one board on all sides of the box, pitching backwards and upwards toward the center, its outer edge flush with the edge of the box. This will give the slope of the top faces, and prevent the concrete from running off the form. The whole form is now filled with fairly dry concrete to the height required, and the top of the concrete sloped off with a shovel or a float. This assumes of course that the top surfaces are nearly flat. The concrete will not run to any appreciable extent if just stiff enough, especially the last few barrow loads.

Forms for footings with steep slopes may be constructed by using a series of frames with vertical sides only 4″ or 6″ high, made to give approximately the batter required. Put down one frame and fill. While the concrete is still somewhat soft, put down the next smaller frame and fill, and so on until the height is attained. After the frames are removed, if the sloping surface is insisted upon, fill the steps with mortar and trowel smooth. If the faces are steep enough to make a complete form necessary clear to the top of the footing, it is possible that the form will have a tendency to "float," due to the lifting action of the wet concrete. This can be avoided with a shallow footing by doing without a complete form on top in the manner just described.

SLOPED WING WALLS

Where wing walls are called for which have slopes corresponding to the angle of repose of earth embankments, these slopes should be finished in straight lines and surfaces, the form of such wing walls and slopes being constructed with its top at the proper slope, so that the concrete on the slope may be finished in short sections, say, from 3′ to 5′ in length, and bonded with the concrete of the horizontal sections before the latter has become set, each short section of sloped surface being grooved with a cross-line separating it from the adjacent sections. The top surface of such sloped walls should not be finished by plastering fresh concrete upon the top concrete which has already set, but the finished work should be made each day as the horizontal layers are carried up, to accomplish which the form should be constructed complete at the outset; or, if the wing wall is very high, short sections of the form, including the form for the slopes, should be completed as the horizontal planking is put in place.

Cast Stone Trim on Lucy Wheelock School, Boston

The accompanying illustrations, of the Lucy Wheelock School, Boston, are shown through the courtesy of Brainerd and Leeds, architects, Boston. The architects say: "We are using cast stone very largely for building purposes, finding it of about the same cost as terra cotta and much to be preferred because it is a solid material—not cast hollow—and because in case of accident in setting it is much more easily repaired. It averages much less in cost than limestone—about $1.25 per ft. as compared with $1.75 for limestone."

The trim stone for the building shown was made by the Puritan Cement Stone Co., at Natick, Mass. The special cast used over the entrance was modeled and cast by A. M. Zottolli & Bros. from a cartoon by W. B. Closson.

Perhaps the most important reason why manufacturers are building of fireproof construction today is to insure a continuity of their market. If, as many do, they sell under a special trade mark, and this is off the market for a number of months, it is difficult to recover the lost ground. The building and contents may be insured; the market cannot. —Leonard C. Wason.

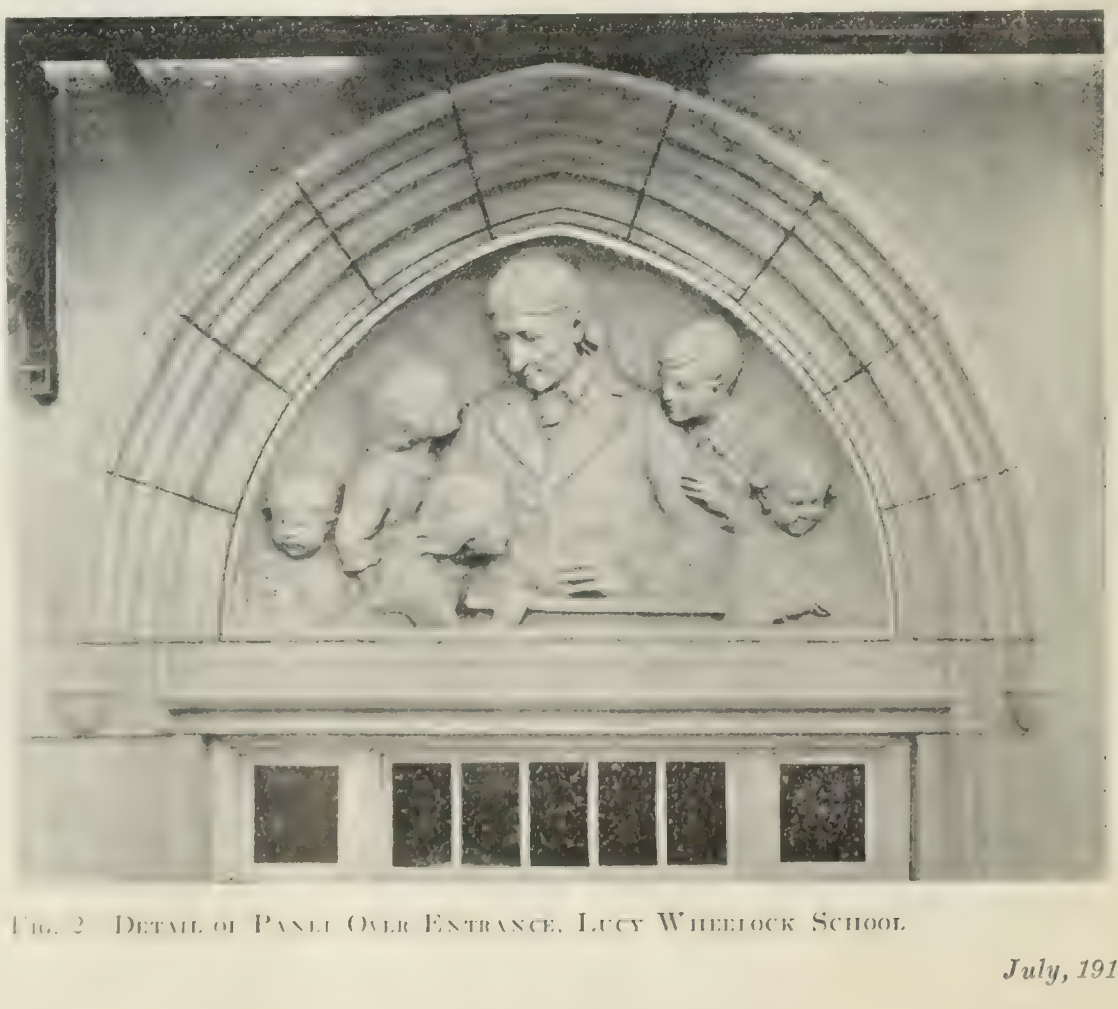

Fig. 2—Detail of Panel Over Entrance, Lucy Wheelock School

Advertising and Selling Methods for Concrete Drain Tile Manufacturers[1]

By J. J. Commons[2]

In order to get a comprehensive idea of the different advertising schemes and sales plans employed by concrete pipe makers, and with the object in view of combining the good points of the different plans and schemes used to promote the sale and use of concrete tile, a general letter was sent to 300 in the states of Ind., Ill., Ia., Wis. and Minn.

While it was not my idea that all the clever sales and advertising ideas would be found in these states, and none in other states in which the concrete pipe industry is profitable, I felt reasonably sure of securing enough information, and samples of advertising used by the different manufacturers, to form the basis of an article of general interest to the industry.

A careful analysis of approximately 200 replies to the letter which requested an outline of sales and advertising plans of the concrete pipe companies has shown that very few manufacturers are making any systematic effort to create a demand for concrete pipe in general, or for any make of pipe in particular. On the other hand, some of the samples of advertising submitted by certain manufacturers were excellent, and in practically every instance, with the samples of good advertising matter submitted, was the statement that sales had been very satisfactory, and no great trouble experienced in meeting the competition of other kinds of pipe.

The majority of manufacturers who replied to my letter said that they realized the necessity of advertising and the need of a business-like plan of selling, but there was a general complaint of lack of ability to prepare advertising matter which could be profitably and advantageously used. A great many manufacturers have been using small newspaper space, but very few of the samples received indicate that any great thought has been given to the preparation of copy, or that the printer had made any effort to give the advertiser good display. In fact, very few newspaper ads were more than card announcements; i. e., simply the name of the manufacturer and the words, "Concrete pipe, blocks, etc."

Newspaper advertising of this kind is of little value, unless possibly the advertiser considers it good policy to patronize his home paper, with the hope of getting some favorable notice concerning the operation of his plant, award of contract, etc.

[*Editorial Note*—Mr. Commons is to be commended for giving no endorsement of or encouragement to these practices. Publishers are improving and will not give editorial or news space to matter with a commercial tinge *because* a manufacturer is an advertiser. Commercial *news* if it is *news* belongs to readers, whether its subject is occupying paid advertising space or not. The man who asks the editor for a "write-up" *because* he is buying white space in which to make advertising announcements is not well informed on ethical progress in the publishing field.]

With the exception of personal contact advertising, I would say that on account of the general lack of office equipment necessary for handling advertising matter of any kind, the best medium for the average tile man is his local newspaper. Good, straight-to-the-point "reason why" copy should be written, and the printer should be made to understand that the ads must be properly set. True, the average tile-maker is not an ad-writer, nor does he understand how to specify type faces and sizes, in order to get proper display, yet I believe that if any tile-maker, especially in the small towns, would go to the manager of his local paper and contract for a space every week, in size, say two columns wide by 6″ deep, by so doing he could get assistance in preparing a good, business-like advertisement.

Whether or not the manufacturer has ability to write an advertisement, he at least should be able to advance some reasons for the selection of concrete pipe in preference to clay tile, and some reason for the selection of his product in preference to that of a competitor. By giving such information to his newspaper man he sould surely get some assistance in preparing advertising. A newspaper man is generally a booster for his town industries and for this reason should be entirely willing to assist a young industry to the extent of helping to prepare display advertising. However, a suggestion of this kind is for the extreme case, and an expedient which should not have to be resorted to too often.

If newspaper advertising is used, it should be changed frequently, both as to display and reading matter. The same arguments used, with different wording and different headlines and different styles of setting, would lend variety to the ad, to give it a greater chance of being read, besides imparting a certain up-to-dateness to the advertisement.

I feel constrained to recommend, especially to the man who does not feel competent to write a good advertisement, the selling assistance offered by certain manufacturers of block and tile machinery. These machinery companies have prepared some very excellent helps for tile makers and block-makers, and I believe this assistance is offered free to block men and tile men who use their machines. And even though I did not use their machines, I think I would not hesitate to request their assistance, if I could not get it elsewhere.

Another form of advertising which has been largely used is small folders of four pages, suitable in size for enclosing in an ordinary envelope. While it is impossible on a folder of this size to give every reason why concrete tile is good and why it should be used in preference to clay tile, such a folder may be advantageously used as a curiosity arouser, or as an introduction between manufacturer and consumer. Such leaflets could be prepared at small cost, in any print shop, and any tile-maker could secure a list of names of prospective customers for his product, so that to circularize every farmer within a reasonable radius of his tile plant would not be an expensive matter.

One-color, two-color and even three-color cards have also been used to a certain extent. Such cards as were submitted were, as a rule, devoted to testimonials from satisfied users, with now and then a picture of a plant or of an important job.

Many tile-makers have printed price cards. These are good. If you are not ashamed of your prices, quote them openely. Don't imagine that you gain any advantage by keeping your prices concealed. If your competitor wants to know your prices, he can easily learn them. Be sure you have the right price and tell a customer quickly and frankly what your prices are when he asks you.

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[1] Presented at convention of Am. Concrete Pipe Assn.

[2] Chicago Portland Cement Co., Chicago

It is not to be understood that any manufacturer can offset the efforts of the clay tile interests and create a big demand for the sale of concrete tile, by mailing one small piece of advertising. On the contrary, it is the persistent, systematic effort that wins in advertising, and frequent advertising efforts, backed up by reliable tile and the right price will get the business.

You must create confidence in your ability to make good tile—you must convince your customers and prospective customers that the tile you offer is as good as you say it is, and leave no room for disappointment on account of poor quality, if you expect to reap the benefits of the cumulative effect of advertising.

It is suggested that every tile-maker secure a copy of Bulletin No. 19 issued by the Association of American Portland Cement Manufacturers, with offices in the Bellevue Court Bldg., Philadelphia, and from this bulletin secure data for his advertising. The U. S. Dept. of Agriculture, and Agricultural colleges in different states, issue bulletins on this subject. The bulletins may be had free of charge and every argument for and against may be considered, and much good advertising prepared by simply quoting from these bulletins, if the manufacturer has neither the ability nor the desire to produce original copy.

One of the successful Iowa companies, at the early period of its existence, induced a professor of the Agricultural college to visit its plant, test several tile of different sizes, and then give a letter showing the result of the tests. The tests were highly satisfactory, and by sending a copy of the college professor's letter to every farmer in the territory, following it later by other advertising matter, such as testimonials from satisfied customers, etc., the company was able to work up a good business. This particular firm planned to circularize its list of farmer trade at least three times a year. It also reports that it has found personal letters to be much more effective than newspaper advertising. Its arguments are along the line of patronizing home industry, results of tests, uniformity of quality, frost resistance, etc.

Since the company under consideration mentions the effectiveness of the personal letters it has used, I wish also to endorse this form of publicity as one of the most effective that I know. However, I have found very few tile-makers in possession of a typewriter, or the time to give to writing very many letters. To circularize a large list with personal letters requires a great deal of time, and unless the manufacturer is so situated that he can take advantage of some of the process letter shops, which are rarely found except in the cities, such advertising, effective though it is, is almost out of the question.

I believe that it is a fact that many of the cement manufacturing companies are willing to assist concrete products plants in an advertising way. They realize the importance of the promotion of the block and tile industry, and any manufacturer desiring advertising assistance should not hesitate to write to the company whose cement he uses, requesting assistance in the preparation of his advertising. Practically every cement company has an up-to-date publicity department and assistance in the preparation of newspaper ads., copy for circulars, mailing cards, leaflets, or letters, would doubtless be cheerfully given to any tile-maker. In fact it is my understanding that some of the cement companies are circularizing the tile people in an effort to induce them to co-operate with the cement manufacturers in an advertising way, and it is to be hoped that some good results may result from this effort.

The subject of advertising is a subject without end, and since this paper is to include some sales information, as well as suggestions for advertising concrete pipe, and because of the length to which I have already gone, I shall briefly outline somt of the sales plans which have been reported by different manufacturers.

One manufacturer in Wis. reports good success from leaving samples and prices with lumber dealers in the neighboring towns, and also from cultivating the acquaintance of the owners of tile-laying machines. He even offers a percentage of his profits to these people, as an inducement to have his tile used.

Another manufacturer in Ia. finds his financial standing and guarantee bond a mighty good assistance in securing business, especially on contract jobs for county ditches.

An Indiana tile maker leaves the manufacture of tile to a competent foreman, and spends his time in meeting prospective purchasers, explaining the merits of his goods and taking advantage of his large acquaintance among farmers in an effort to make sales.

An Illinois tile manufacturer, who also makes brick, block and stave silos, has found personal solicitation to be the best sales method. His company has also attended fairs, both state and county, with samples of its product. By this method it meets many prospective purchasers, but some manufacturers who have tried this scheme say that they have found that a great deal of their time has been given to prospects from points to which they could not make shipment.

An interesting communication comes from a small Iowa town. The manufacturers have been especially successful in securing contract jobs. Their method is to make a strictly high grade tile, and one which will stand the most rigid tests. Then, when a contract is to be let they get the men who are to pay the bills (the farmers), taken them in an auto to the plant, prove the quality of the tile, and, through friendship and salesmanship, induce the farmers to recommend their tile to the Board of Supervisors. This firm is quite sure that any man who objects to concrete tile either knows nothing about them or has had an unsatisfactory experience with a tile of poor quality. If they make a talk as good as the letter they wrote explaining their methods, their success is not to be wondered at.

A Minnesota company reports that it has been working on the supposition that if it turns out a good tile at the right price, sales will be easily made. Representatives attend ditch lettings, and never overlook a chance to talk quality rather than price. The fact that they have recently doubled the capacity of their plant, having already enjoyed a large business in the past, is indication that quality counts and that the consumer is susceptible to their argument and appreciative of high quality.

To sum up, I would say: Make a strictly high-grade pipe and do as much advertising as you can, practice the sales method of successful companies, if you have no plans of your own, secure the assistance of block and tile machinery manufacturers, and the cement companies, if you do not feel competent to handle your own advertising, boost concrete tile every day in the week and every week in the year, and you have good prospects for success. Your company may not be a money maker at present, but since so many others have prospered, there should be no good reason why you also should not enjoy prosperity if you study your proposition in a business-like manner, and apply the methods which have been successful with others.

A Chart for the Design of Concrete Slabs

The accompanying chart for use in designing floor slabs is contributed by H. C. McClure, C. E.[1]

It will be found well worthy of a place in the private notebook of the engineer and draftsman.

Its use is best illustrated by the following example:

Example.—Given a simple span of 8′ with a live load of 200 lbs. per sq. ft. Assume that it will take a 6-in. slab to carry, having a 4-in. fill and finished floor = say 100 lbs. per sq. ft. = total load of 300 lbs. per sq. ft.

Solution.—Start at left-hand side, top section, at 8-in. column marked "span of slab in feet." Follow horiontal line to curve marked 300 lbs., drop vertically to curve in center section. From this point drop to "effective depth of slab" (equals 5″) and also move to left to "area of steel per foot width of slab" (equals .41).

Add to "effective depth" an amount required for fireproofing (say 1″) which gives a total thickness of slab of 6″.

In the "table of areas and weights" at the bottom .41 sq. in. equals 3/8″ at 3-in., 7/16″ at 4½-in. or ½″ at 5½-in. centers.

Therefore a 6-in. slab with one of above rod systems will be used.

Given the same span and load for a slab continuous on both ends. Start as before—to intersection of 8-ft. line and 300-lb. curve — equals 28,000 inch-pounds (at top of sheet). Reduce the 28,000 lbs. by ⅓ = about 19,000 inch-pounds. Start at 19,000 inch-pound line and proceed as for simple span. Gives 5-in. slab — with 3/8″ at 4-in. 7/16″ at 5½-in. or ½″ at 7-in. centers.

For a span continuous on one end only, reduce moments in inch-pounds by .2 and proceed as above.

If the original assumption, as to the thickness of slab required, varies too much from final result, assume a new thickness and refigure dead and total loads.

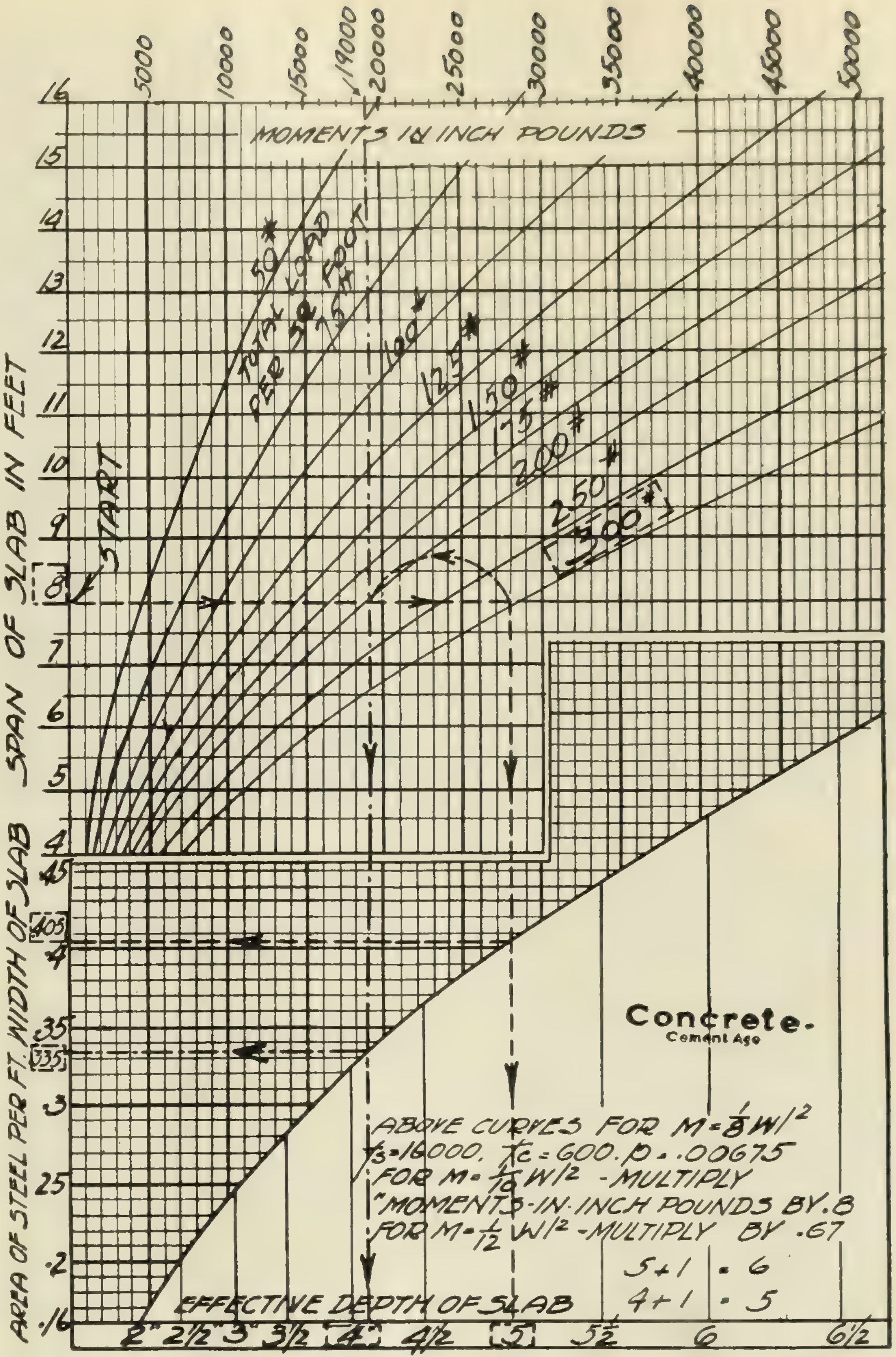

TABLE OF AREAS & WEIGHTS OF RODS FOR VARIOUS SPACINGS

SPACING	1/4		5/16		3/8		7/16		1/2		5/8	
	A	W	A	W	A	W	A	W	A	W	A	W
3″	.197	.668	307	1.041	.440	1.56	.6	2.22	.785	2.67	1.23	4.18
3½	.169	.572	.264	.895	.378	1.29	.515	1.755	672	2.29	1.054	3.584
4	.147	.5	.230	.782	.330	1.13	.458	1.533	589	2.0	.92	3.13
4½	.131	.445	.204	.695	.293	1.00	.399	1.360	.521	1.775	.816	2.78
5	.118	.4	.184	.626	.264	.905	360	1.227	.471	1.60	.736	2.508
5½	.107	.344	.167	.569	.240	.814	.327	1.114	.428	1.455	.669	2.275
6	.098	.334	.154	.522	.221	.752	301	1.022	.392	1.335	.614	2.088
6½	.091	309	.142	.483	.202	.676	.278	.956	.363	1.235	568	1.93
7	.085	.287	.132	.449	.189	.647	.258	.880	.337	1.15	.528	1.795
7½	.079	.267	.123	.418	.176	.601	.240	.818	.314	1.07	.491	1.67
8	.074	.251	.115	.392	.165	565	.225	.767	.294	1.0	.460	1.565

A Chart for the Design of Concrete Slabs

A Concrete Building is Truly Manufactured

In an address before the Natl. Assn. of Cotton Mnfrs., Boston, on "Uses for Concrete Construction by Cotton Manufacturers," Leonard C. Wason, C. E., Pres., Abertaw Constr. Co., Boston, said:

It should first be noted that the building of reinforced concrete is a manufacturing proposition. Crude materials, sand, stone, cement and water, are combined with each other, placed in forms which are previously made to hold the plastic material, which is poured around reinforcement previously set and secured in position, and a new material is thus manufactured in place. This is a more difficult proposition than assembling. The building of mill construction is largely that of assembling. One brick is piled upon another with mortar between. Wood is put in place with very little change from its original form. For this reason, a better type of builder is desirable for a reinforced concrete building than for the other. A manufactured article is either right or wrong; there is no half way about it. If it is concrete and if it is wrong, it must either be accepted as it is and remain wrong, or else it must be torn down and done over. Hence the great importance of doing it right the first time.

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[1] Structural Engr., Toledo, Ohio

Good Results with Oil as a Waterproofing Ingredient in Concrete

The use of oil as a waterproofing in concrete mixtures has been under investigation by the U. S. Office of Public Roads for some years. The possibility of satisfactory results with such mixtures is now officially announced, in a statement from the Dept. of Agriculture, summarizing a new bulletin of the Department.[1] The statement follows:

> The conclusions to be drawn from the tests are that the admixture of certain mineral oils in small proportions, not to exceed 10% of cement used, does not lessen the tensile strength of mortar; that the decrease in the compressive strength of mortar and concrete is not serious; that concrete mixed with oil takes much longer to set hard, perhaps twice as long, but that the increase in strength is nearly as rapid in the oil-mixed material as in the plain concrete. The use of oil does not make the concrete impervious to heavy water pressure, but it does make it practically non-absorbent under low heads.
>
> The value of oil-mixed concrete is said to be particularly great in the construction of basement floors and walls, watering troughs, cisterns, barns, silos, and in all parts of concrete structures that are to be made damp-proof.
>
> The oil should in no case exceed 10% of the weight of the cement and for the most part, 5% is all that is necessary. Since a bag of cement weighs 94 lbs., 4.7 lbs. of oil, or about 2½ qts., should be added for each bag of cement used in the mixture. The sand and cement should be first mixed with the proper amount of water into a stiff mortar, to which is added the correct amount of oil, and the whole mass again thoroughly mixed until all traces of oil have disappeared. Particular care should be taken to insure that the oil is thoroughly incorporated in the mixture and the time of mixing should be practically double the amuont needed when the oil is not used. For this reason a continuous mixer should not be used in oil-cement-concrete work, as it is difficult with this type of machine to increase the time of mixing sufficiently.
>
> The kind of oil is also important and the following technical specifications are suggested in the bulletin in order to prevent the use of certain oils which might tend to impair the strength of the mortar or the concrete.
>
> (1) The oil shall be a fluid petroleum product and shall contain no admixture of fatty or vegetable oils.
>
> (2) It shall have a sp. gr. not greater than 0.945 at a temperature of 25° C.
>
> (3) It shall show a flash point of not less than 150° C. by the closed-cup method.
>
> (4) When 240 cc. of the oil is heated in an Engler viscosimeter to 50° C., and maintained at that temperature for at least 3 min., the first 100 cc. which flows out shall show a specific viscosity of not less than 15 nor more than 30.
>
> (5) When one part of the oil is shaken up with two parts of hundredth normal caustic soda, there shall be no emulsification, and upon allowing the mixture to remain quiet the two components shall rapidly separate in distinct layers.
>
> For practical use the addition of oil will be found particularly useful in the construction of basement floors and walls. Many of these now in existence are continually damp and such a condition may be remedied by the application of an oil-mixed mortar coat to the old surface. A mortar composed of 1 part of cement and 2 parts sand and containing 5% of oil should be sufficiently non-absorbent for this purpose.
>
> Watering troughs and cisterns made of oil-mixed concrete should also prove of considerable practical value in the conservation of water. In the construction of barns, where oil-mixed concrete is used, the interior will be noticeably drier than when ordinary concrete is used. Owing to their durability, cleanliness and resistance to fire, concrete barns are becoming more and more popular, but they suffer from the disadvantage that during a long beating rain the side walls are inclined to absorb much moisture, which ultimately penetrates into the interior. The addition of oil to the extent of 5% of the weight of cement in the concrete used in the side walls obviates this objection. Barn floors can also be constructed in the same way with advantage. A damp-proof floor is warmer because of the lack of evaporation from its surface, and it is also more sanitary than an ordinary concrete floor because of its non-absorbent character.

There are, of course, any number of other types of buildings and structures of all sorts in which oil-mixed concrete may be used advantageously, or, if this is not necessary, a coat of oil-mixed mortar may be applied effectively.

Attention is called, however, to the fact that extreme care in proportioning, mixing and placing the concrete is absolutely necessary if the addition of any waterproofing agent is to be of value. The process of mixing oil with concrete has been covered by a public patent so that anyone is at liberty to use it. The methods of using this material are discussed more fully in the bulletin already mentioned.

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[1] Bulletin No. 230, Dept. of Agriculture: *Oil-Mixed Portland Cement Concrete*

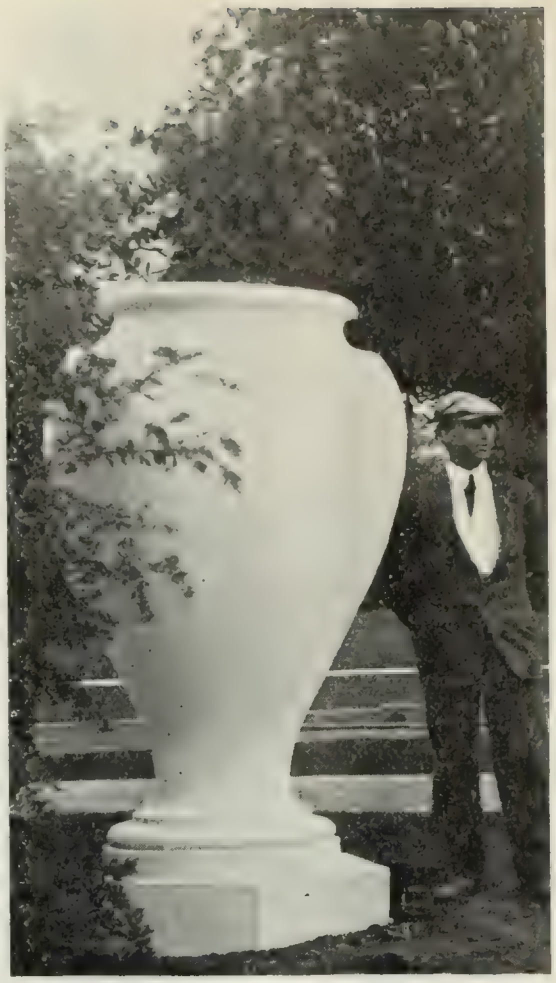

Fig. 1

Concrete Urn More Than 6′ High Made In Plaster Mold

The concrete urn shown in Fig. 1 is one of two, just alike, made by H. R. Schmohl, a contractor, specializing in exposition work of an ornamental character. The urns stand at the entrance to an exposition building at San Diego, Cal.

The urns stand on concrete bases and were made in place. The height, not including the base, is 6′. The diameter is 4′ at the largest part and 28″ at the base. Each urn was made in a plaster mold, a negative of the urn, ⅔ of its height, in two parts, seam running from top to bottom; the remaining ⅓ was in three pieces. This method was employed to overcome handling material over inconvenient height; as it was built up, the pieces were added one on top of the other. The mixture 1:2, was made damp for tamping carefully to assure a good stone-like face. A sand core was used and filled in as the work progressed toward the top. When the mold was all filled it was well saturated with water, and allowed 3 das. to harden; then the sand was removed through the top opening, and more time was given to curing; after this the plaster mold was removed. Fig. 2 gives an idea of the division of the plaster mold.

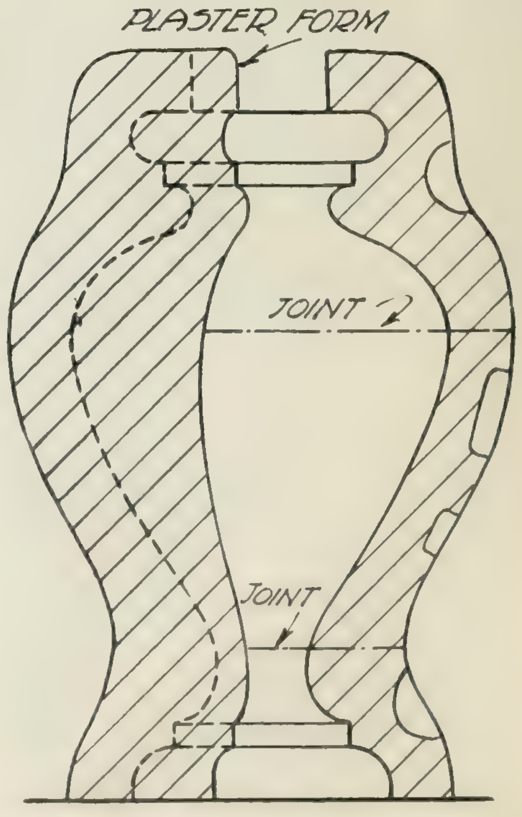

Fig. 2

Information and Consultation: The How-to-Do-It Department □ □ □

This magazine is for service. Let it serve you, and you help it to serve. You want special information. Ask us. We know the men who know.

Effect of Sewage and Sewage Gases on Concrete □ □ □ □ □

THE QUESTION BELOW IS DISCUSSED BY:
RUDOLPH HERING[1]
T. CHALKLEY HATTON[2]
HARRISON P. EDDY[3]
A. MARSTON[4]

"Can you cite evidences of the disintegration of the surface of concrete where sewage has come in contace with it?"

BY MR. HERING

We have plenty of cases in which cement concrete has been used for sewers, extending over a great many years, not to refer to the old concrete sewers of Rome and London, on which I have no detailed and satisfactory information.

I know that the large sewers in Paris have been built of rough stone heavily plastered and smoothed with cement so that the sewage flows over the cement surface in the same way as if the entire mass were of concrete. These surfaces at my examination in Paris were quite good. There had been no disintegration. I laid this fact to the density and smoothness of the plaster.

In 1881 I closely examined the concrete sewers in Vienna, where many had been built both of large and of medium size. The work had been very carefully done and the sewers had been built from 10 yrs. to 20 yrs. The sewage is rather strong in Vienna, because the water supply per capita is unusually small. I found no disintegration of the concrete surface, which then looked dense and smooth.

The city of Washington was the first city in our country that built concrete sewers to any great extent and it would be of interest to know how they have held out.

I have seen some sewage tanks in Europe, particularly those at Hampton, south of London, in which the sewage had very much disintegrated the concrete and cement of which the tanks were built. The sewage of Hampton is much stronger than the average sewage in the U. S. I noticed that the original concrete did not seem to have been very dense and, therefore, the sewage had been absorbed by capillarity and caused a decomposition. There were patches on the walls of the tanks which showed no disintegration. Their surfaces were invariably smooth and showed no great porosity. They were discolored, but not soft.

BY MR. HATTON

Replying to your inquiry, for an expression as to what, if any, effect sewage or sewage gases have on concrete, so far as my observation goes, I beg to advise you that I have been building concrete sewers since 1893.

I have had charge of the operation of these sewers up to 1906, during which time I have had occasion frequently to pass through them for examination and inspection, and have never seen any visible effect upon concrete exposed to sewage or sewage gases which might have resulted from the action of the sewage, and I am of the opinion, broadly speaking, that if the concrete is of the proper character, built and placed in the proper way—that is, a dense enough mixture and properly mixed—the ordinary sewage or sewage gases generated from an American city will have no effect whatever upon the concrete.

BY MR. EDDY

We have seen an unquestionable instance of the injury of concrete by sewage at Hampton, England. This was on the concrete walls enclosing a contact bed, where gases from the sewage had weakened the concrete so that large flakes ½″ or more thick were readily detached. Another well known English instance of such action has been at Nuneaton. It is generally believed that septic sewage or gases therefrom caused considerable injury to concrete at the sewage treatment works at Saratoga Springs, N. Y. Concerning a report on this we refer you to the designing engineer, Frank A. Barbour, of this city.

Our views on the general subject are given in the following extract from the second volume of our treatise on *American Sewerage Practice:*

> Concrete being of a calcareous nature is affected by acids, some of which may be discharged from industrial establishments like wire-drawing and pickling factories, or they may be formed indirectly by the decomposition of the sewage, during which process hydrogen sulphide is formed and may be given off into the air in the sewer when it comes in intimate contact with the concrete. While dry hydrogen sulphide gas does not appear to attack concrete, it is easily oxidized in the presence of moisture to sulphuric acid, which may have a deleterious action. Some structures, like concrete septic tanks and the brick outfall sewer at Los Angeles, have been seriously disintegrated through the action of acids, resulting from the decomposition of sewage and the evolution of hydrogen sulphide. Such action is equally injurious to concrete and to mortar in the joints of brickwork, but brick masonry possesses the decided advantage over concrete that these joints can be easily raked out and re-pointed,—a process which is not applicable to a concrete arch, repairs to which must be more extensive and done at considerably greater cost.

The fact that we recommended the use of concrete for the large sewage treatment works at Fitchburg, Mass., now nearly completed, will indicate to you that we regard concrete as a suitable material for such plants, and we recommended the construction of many miles of large and small concrete sewers at Louisville, which have shown no signs of deterioration by sewage, so far as we know. On the other hand, if we believed that the sewage of a city might contain industrial wastes liable to attack concrete or might become so decomposed at a treatment plant that the evolution of large quantities of hydrogen sulphide was possible, we should give the subject a more thorough investigation than the needs of any of our clients have yet rendered desirable.

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[1] Hering & Gregory, Cons. and Sanitary Engrs., N. Y. C.

[2] Chf. Engr., Sewerage Comm., Milwaukee

[3] Metcalf & Eddy, Cons. Engrs., Boston

[4] Dean and Director, Div. of Engrg., Ia. State Coll., Ames, Ia.

By Mr. Marston

The only cases of disintegration of concrete by sewage which I have seen are in connection with sewage tanks above the water line and especially around man-holes and other openings to the air. There is sometimes a disintegration due to oxidation of hydrogen sulphide, forming sulphuric acid, which attacks the concrete. This disintegration does not occur below the water line and can generally be noticed only in case there is an excessive amount of sulphur compounds in the water supply.

I have seen only one case in which this disintegration was serious, namely, at the hospital for Inebriates* at Knoxville, Ia.

On the other hand, we have taken up on our grounds cement sewer pipe which had been in the ground over 30 yrs., carrying sewage constantly from our former main College building, and which showed no disintegration from the sewage. Above the normal water line the gases seemed to have cut the cement just enough to let the sand grains show through, but so far as I could see, this effect had not penetrated more than $\frac{1}{32}''$, the total thickness of the shell being $1\frac{1}{4}''$.

In fact the old College main building, which this sewer was built to serve, has since been destroyed by a conflagration, although built of heavy masonry, and the cement sewer in question is now still serving the new College central building, and so far as I can see is likely to remain in good condition for generations to come.

I have been informed by various city engineers, however, that in cases in their experience in which cement sewers had been exposed to extremely hot water, or to chemicals in the waste of certain factories, disintegration had occurred.

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*Is *this* a fair comparison?—Editors

Concrete Sign Boards for Highways

The Question Below is Discussed By:
Wm. M. Kinney[1]

"A correct, intelligible and permanent "label" is an essential in highway construction. The painted sign board (wood, of course) has been in use from time immemorial. Concrete is the material for highway construction.

"Why couldn't the direction signs be formed of concrete boards, with the letters indicated by a suitable inlay, tile, metal, or a differently colored concrete?"

By Mr. Kinney

There is no reason why an entirely satisfactory sign board can not be made from properly reinforced concrete. Any inscriptions or lettering desired can be inlaid by the method commonly employed among all ornamental cement workers; namely, placing against the face of the mold paper upon which selected colored aggregates have been glued so as to form the desired inscription or lettering. When forms are removed water applied to the paper will soften the glue and thus release the paper, leaving the ornamental figures thoroughly embedded in the concrete, in the form of mosiac work. While the expense of such sign boards would undoubtedly exceed that of the wood boards to which we are all so accustomed, there would be no expense for paint, repair or renewal, and the ultimate cost would be less than for sign boards of the type now most common.

Concrete-Cement Age for May, 1913, described on p. 225[2] the operations of W. H. Filer, Grove City, Pa., saying:

> "Another one of Mr. Filer's recent developments is the use of colored lettering cast in such products as street signs, monuments, etc. Cement is used in this secret composition and just how the work is done Mr. Filer has not made public. The material used in this lettering extends into the block of concrete about $\frac{3}{16}''$ to $\frac{1}{4}''$ and is dovetailed with the inner section larger than the outer, so that there is never any loosening of the letter. This development has made it possible for Mr. Filer to go into several special lines. These include street signs, railroad signs showing distances to stations, monuments and also railway mile posts. The mile post is made triangular in section, 7′ long, having two faces which are 10″ wide, in which the letters and figures are cast in a white Portland cement background."

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[1] Engr. in Chg., Inf. Bur., Universal Portland Cement Co., Chicago

[2] See also elsewhere in this issue—Editors

Concrete Tanks for Dye Houses

The Question Below is Discussed By:
Rolf R. Newman[1]

"We are constructing some reinforced concrete tanks for a dye house. Since their construction began, it has been claimed that water used from a concrete tank would be injurious for dyeing purposes. The question involved is simply whether or not the water stored in such a tank will absorb anything from the concrete."

By Mr. Newman

The most common use that I am familiar with of concrete for use in dye houses or laundries is for holding the bleaching mixtures. One laundry that I know of has used a 2-ft. length of 24-in. diam. cement pipe, in which a cement bottom had been placed, for a "bleach" holder for the past two years. The cement has not been affected by the chloride of lime and soda constituting the bleaching mixtures.

The question of water for dye purposes being affected by the concrete of the tank containing it is somewhat different, but in any normal mixture of good concrete the action is rather a slight absorption of water in the further hardening of the concrete than any absorption by the water from the concrete. When a tank of this kind was first used there might easily be some excess of lime on the face of the concrete that would be absorbed by the water, but when this first water was once drawn off the action would not continue.

Such absorption as seems to be feared by your questioner would involve the eventual disintegration of the concrete, but as such disintegration does not occur with the bleaching mixtures it is reasonable to suppose that the less active water used for dye purposes would not be injured by concrete. Further evidence is at hand in the fact that sea water, which is chemically active, has practically no effect on properly proportioned concrete. Further, in Concrete-Cement Age for Feb., 1913, page 74, is evidence to the effect that ammonia liquor does not act on concrete, so that unless very unusual conditions are present your questioner will be perfectly safe in using concrete for his dye house tanks.

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[1] Civ. Engr., Riverside, Cal.

Protection of Concrete Against Alkali ☐ ☐

THE QUESTION BELOW IS DISCUSSED BY:
RAPIER R. COGHLAN[1]
R. A. HART[2]

"Will a rich mixture protect concrete permanently when black and white alkali are in the ground? Or, when the water flowing in a canal system is rather heavily charged with alkali for about two months during each irrigation season?"

BY MR. COGHLAN

Black alkali is a rare component of soils in the Southwest, while the white alkali is quite common in some districts. The existence of calcium sulphate in nearly all the western waters renders the presence of black alkali in the water impossible, consequently there is none transferred to the soil by irrigating water. The white alkali and gypsum exist together in these waters, and no instance of disintegration of rich concrete has come under my notice.

Particular attention is called to a 55,000-gal. water tank, which was constructed of 1:2:4 Portland cement concrete. A standard brand was used with ordinary river sand and basaltic aggregate. The pouring was not continuous, with the result that at nearly every place where the joint was broken there was some leakage when the tank was filled. Later each joint was chipped out to a V-shaped notch about 1½" deep, the notch being filled with neat Portland. This remedy helped some, but the tank continued to leak, with the result that a considerable deposit of white alkali formed on the outside of the tank. As the water level within the tank constantly varies, this deposit is alternately wet and dry. The tank is now four and one-half years old, and there is no sign of the concrete suffering from contact with the alkali. I personally believe from the evidence gathered from experiments with concrete in the present of alkali, that rich concrete is the best antidote for alkali when in the sulphate form. My experience with black alkali is negligible.

BY MR. HART

I have very little to offer on the subject in question but I will call your attention to the fact that in localities where concrete has been known to disintegrate, I have observed that red sandstone, either placed in foundations or lying as broken stone or boulders in the open fields, is readily attacked by the same soluble salts that destroy concrete structures. The action seems to be one on the bond between the grains of sand, as the stone after disintegration presents a loose mass of sand having crystals of salt and salt powder between the grains and coating the entire mass. In such destruction it is an easy matter to tear a sandstone boulder to pieces by means of the hands. It has always been my opinion that the iron cement which originally held the matter in a solid mass was the substance attacked by the alkaline salt.

DISINTEGRATION OF RED SANDSTONE FROM SODIUM SULPHATE

The accompanying illustration shows a red sandstone boulder, about 2′ wide, which is rapidly being disintegrated by the action of sodium sulphate. The large cavities appearing in the boulder represent the portion of the boulder which I removed as loose sand, by means of my hands. It will be observed that numerous cracks appear in the surface of the boulder. In some instances, the first sign of injury is the appearance of the cracks, and the outer layer of sandstone may be removed much as the shell of the English walnut is taken off, while the inner portion consists largely of loose sand. It will also be observed that the white efflorescence not only intermingled with the disintegrated particles of the boulder, but covered the ground surface as well.

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[1] Mfg. Cement Chem., U. S. Reclamation Service, Dept. of the Interior, Elephant Butte, N. M.

[2] Supervising Drainage Engr., U. S. Dept. of Agri., Salt Lake City, Utah

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A feature of the last meeting of the Assn. of Am. Portland Cement Mfrs. in Chicago May 12 and 13, was a visit to Milwaukee, where an inspection was made of the concrete roads and pavements of that city and vicinity. Some 40 mi. of concrete roadway were traveled over by a body of about 120 men.

Discoloration of Concrete Sidewalk from Oak Sawdust ☐ ☐

THE QUESTION BELOW IS DISCUSSED BY:
JULIUS RUOFF[1]
BENJAMIN A. HOWES[2]
WM. M. KINNEY[3]
R. L. RICKMAN[4]

"We put down a concrete sidewalk and covered it with oak sawdust and find that the sawdust has badly discolored the walk. Can you suggest a wash of some kind that would restore the walk to its natural color?"

BY MR. RUOFF

Covering a concrete sidewalk with oak sawdust is very bad judgment, as this sawdust will discolor as soon as it gets wet or damp. To restore the natural color is probably impossible. A strong solution of muriatic acid and water might be tried to remove the stains. Salt, hay or felt paper, or dry sand will give the same protection for light freezing weather and will make no spots which will not wear off.

BY MR. HOWES

Several years ago I found some discoloration of granolithic floors where we had covered the work with wet sawdust, which I judged at that time to be due to the sawdust used. Since then we have always used sand to conserve the moisture in the surface.

BY MR. KINNEY

An English trade journal states that oil stains on concrete floors may be removed by using a mixture of 1 lb. of oxalic acid dissolved in 3 gals. of water, with enough wheat flour added to make a paste that can be applied with a brush. Allow this to remain on the stain for two das. Then remove by scrubbing with a brush, and clean. A second application, if necessary, will be found sufficient to remove the most stubborn case.

The foregoing paragraph is quoted from *The Dealers' Material Building Record*, for July, 1911. We have not tried this, but it seems to us worth trying.

BY MR. RICKMAN

While I am a resident of what is generally known as the "Sawdust

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[1] Ruoff Constr. Co., Philadelphia

[2] Engr. and Contr., N. Y. C.

[3] Engr. in Chg., Inf. Bur. Universal Portland Cement Co., Chicago

[4] Contr., Eau Claire, Wis.

City," yet I must confess that I have had no experience of the kind in question. I might add, however, that if a real permanent color stain for concrete has been found in sawdust, it might be turned to good advantage.

I believe that all public sidewalks made of cement should be colored green for the protection of the eyes and to reduce the radiation of heat in summer. And as the question of sidewalk discoloration has been raised, I believe it an opportune time, if permitted to do so, to bring, what I believe an important matter before the public. "Sight" is the most important of our senses. Why destroy it with glaring sidewalks when green ones would protect it? We have been trying to inject a little common sense into concrete work generally, now let us inject a little beneficial coloring into it.

Attaching Machinery or Piping to Concrete Floors

The following is an extract from an address by Leonard C. Wason, C. E., Pres., Aberthaw Constr. Co., Boston, delivered before the Natl. Assn. of Cotton Mfrs.:

It is an easy matter either to embed inserts in the floor for attaching shafting, piping, etc., in a prearranged method, or to insert these so that timbers can be bolted to them and allow an elastic method of attachment. Again it is fairly simple to drill holes for the insertion of expansion bolts, where no previous provision has been made. The cost of setting these inserts varies with their style, but for material and labor may be said to run between 5 cts. and 10 cts. each. They can be attached as readily to corrugated iron, which is today very extensively used for form work, as to the wooden panels which were used most extensively some years back. Corrugated iron is much cheaper to use for form work than wood panels, and the writer thinks it makes a much better looking ceiling.

Pergola with Concrete Columns, Girders and Beams and a Wood Lattice in Grounds of O. C. Barber Barberton, Ohio. Built by O. C. Barber Concrete Co.

Correspondence: A Department in Which the *Reader* Becomes the *Writer* □

This is your department. It is informal. Use it. This is the place for letters which have either inspiration or information for the "other fellow." It is well to remember that you are usually in his position. If you are to get the good out of these columns, why not help to make them good? Write about your work. Help the Other "other fellow." □ □ □

Concrete Dance Floors

A Letter From Homer Laughlin, Jr.[1]

[*Editorial Note* — Inquiry was made recently by the engineer of a city park dept. as to the possibility of finishing a concrete floor to make it suitable for dancing. He was building a park dancing pavilion and wanted a concrete floor in it. This magazine, among other inquiries, asked information of Mr. Laughlin, whose interesting letter on concrete floors in dwellings appeared in this dept. in Jan., 1915.]

The floors of my house are of concrete, with which were mixed yellow ochre and metallic red until there was obtained in the top finish a color approximating the one we desired. Then with good artists' colors, spots of sap green, lake green, vermilion, rose madder and sepia were daubed on at random. Then a pounce was made of cloth and padding and the surface was pounced over until these colors were drawn more or less together, but still leaving an uneven tone in the floor.

After the artists' colors were all in place, a coat of varnish was put on and it was then waxed. We have not had much occasion to use our floors for dancing until quite recently. We have danced on them only four or five times but our guests seemed highly pleased with the floors. The only difficulty that I have observed is a tendency to be too slippery after a little use and I think this could be overcome by using a very coarse sand in the top dressing.

The average floor finisher likes to use a concrete for his top dressing that is very rich in cement. I call your attention to the fact that the leaner in cement this top dressing is made and the more sand (or non-shrinkable material) there is in it, the less will be its coefficient of contraction. The secret in getting a good surface is to use coarse sand, no more cement than necessary, and plenty of "elbow grease."

I am told by Mr. Gill,[2] my architect, that he has put down floors for dancing where he paid no attention to the color of the cement when laid; treated it with acid to kill the alkali and to render it of a peculiar shade, and then varnished and waxed it, with good results.[3]

I think it better that those who undertake to make a floor for dancing should figure out broadly the principles involved as outlined herein and be governed a little by local conditions as they find them.

I am inclined to believe that the spring obtained from wooden floors and also by placing elaborate rubber cushions under them is more imaginary than real, since on inquiring of one or two of my friends whether or not they enjoyed dancing on concrete floors, they remarked that they had not realized that my floors were of concrete and had not noticed the difference.

I am not fully prepared to say that a concrete floor is positively as good as a wooden one for dancing. This will have to be tried out on a large scale to prove the point, but I do believe that a concrete floor will be reasonably satisfactory for this purpose.

A description of the treatment of the concrete floor in the Coliseum, Chicago, to put it in shape to be danced on was published in the *Universal Bulletin*,[4] Feb., 1912.

The floor was first washed with water applied from a fire hose and was then given a thorough scrubbing by placing wire brushes in an electrically operated polishing machine, afterward scrubbing with stiff bristle brushes. When thoroughly dry, a preparation known as Minwax[5] was rubbed on the floor, care being taken to allow as much of the preparation to be absorbed as possible, although none of the surface was gone over the second time. The floor was then treated with ordinary floor wax applied by hand so as to secure a uniform application. Wax was rubbed into the floor under about 35 lbs. pressure by means of brushes attached to the rotary polishing machine. Finally, a piece of soft cloth attached to the brush holders was used for polishing.

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[1] Los Angeles, Cal.

[2] Irving J. Gill, San Diego, Cal.

[3] A solution of zinc sulphate and water, equal parts, is the usual application on concrete before applying ordinary linseed oil paints—Editors

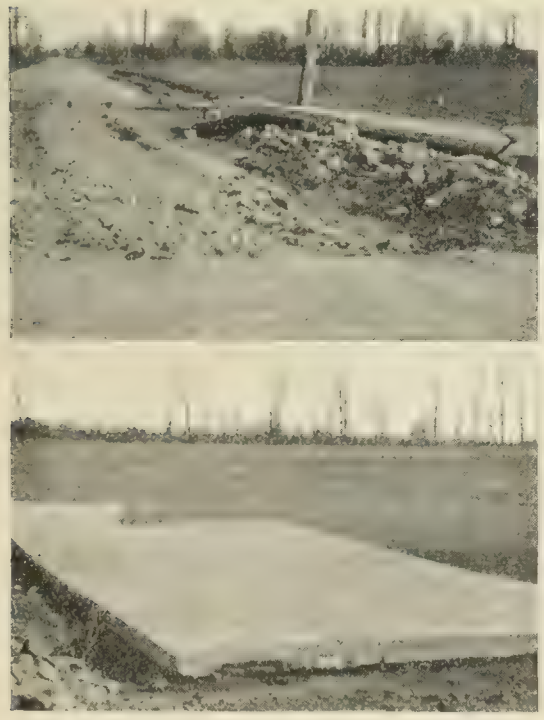
[4] Universal Portland Cement Co., Chicago

In a number of places where the floor had worn a little before treatment, the roughness was remedied by the process described, and the subsequent use of the floor by dancers showed that the results obtained were apparently satisfactory, as there were no complaints concerning the surface.

Concrete Road Slabs Moved by Flood

A Letter From H. Colin Campbell[1]

Last year, 1,300′ of what is known as the Henderson Road, near Evansville, Ind., was paved with concrete. This was reinforced, laid 15′ wide, with expansion joints every 30′, thus making the slabs 15′ x 30′. Recently the Ohio river overflowed this road and reports say the current reached 40 mi. per hr. At any rate, the illustrations show that there must have been "some current" to have lifted these slabs, weighing approximately 21 tons each, from the roadbed, and placing at least one of these slabs 30′ from its original position. Six or seven other slabs were thrown out of place or out of line and with but one exception suffered no particular injury, thus showing what properly constructed concrete pavement will stand under unusually adverse treatment.


Two Views Showing Flood Action on Concrete Road

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[1] Chicago
[5] Minwax Co., N. Y. C.

Expansion Joint Filler In Sidewalks

A Letter From Walter H. Heimbuecher[1]

In regard to using expansion joint filler in sidewalk construction, I have seen quite a number of sidewalks rear up on a hot summer day, like a broncho, in fact, took a header over just such a place returning home one night. The aforementioned place was perfectly smooth at 7:00 p. m. when I went out, and as the street is very poorly lighted I did not see the hump. On investigation the next day I found that the one slab had broken, crumbled where the edges were in contact and the lap amounted to about 2″. This occurred in a stretch of sidewalk 1,000′ long on a 3% grade with an open joint every 5′—that is, the block were 5-ft. sections and the joint about ¼″ with a 2-in. open expansion joint 100′ from the bottom of the hill. The break occurred about half-way up the hill on a summit where the 3% flattened to a 1% for a short distance and then continued on a 3% again. I found the joints full of dirt and clay, the expansion joint full also, so decided that its usefulness was in the neighborhood of 0%, and something better in the nature of expansion joint necessary. Incidentally, *I* didn't build that sidewalk. Have also noticed in the city of St. Louis, places where the sidewalk, at street corners, had expanded to such an extent as to break off 6″ to 8″ of curb from a combination concrete curb and gutter where the water line was 10″. Following is the way my specifications read:

> A ½-in. expansion strip of Carey Elastite[2] or its equal shall be placed transversely in the pavement for its full width and for the full depth of the concrete, at street corners, where the sidewalk meets the back edge of the curb, and at intervals of 50′ in the balance of the work.

The addition of the expansion strip to the specifications has not increased the cost whatsoever, as it would only amount to about 30 cts. in 300 sq. ft. of sidewalk, which is almost negligible.

Cannot give any information as to results, for the first job laid under the new specifications was completed in the middle of Nov., 1914. I intend keeping close watch on one stretch in particular, which is 650′ long.

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[1] City engr., University City, St. Louis, Mo.
[2] Philip Carey Co., Cincinnati

An Efficient and Inexpensive Filing System

A Letter From G. W. Smith[1]

In my four years in college I accumulated a more or less valuable collection of data and information pertaining to my course in architectural engineering. It consists of magazine articles from technical magazines, text books, trade literature and catalogs, and reports from the Engrg. Experiment Sta. at the Univ. of Ill.

No matter what the quantity or how good such information may be, it is of little value unless it can be located in a reasonable length of time. I had trouble in finding what I wanted and in many instances forgot that I had certain information, so I hit upon a plan to obviate this difficulty.

The system I use is that of the "card index." This system is elastic and can be suited to the pocket-book of the individual. For the beginner the necessary expense is small. Being something of a carpenter, I made my own card cabinet, although there are many on the market. The following sketch will give some idea of what is needed:

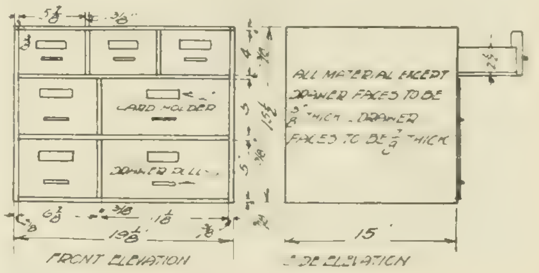

5 7/8
3/8
CARD HOLDER
DRAWER PULL
6 7/8
19 1/8
15
ALL MATERIAL EXCEPT DRAWER FACES TO BE 3/8 THICK. DRAWER FACES TO BE 7/8 THICK
FRONT ELEVATION
SIDE ELEVATION

Fig. 1

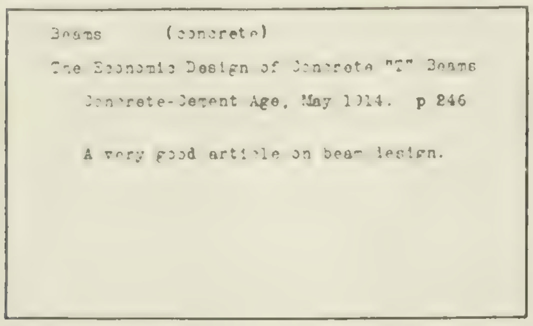
The three top drawers are for 3-in. x 5-in. cards and are my reference files. I am a subscriber to Concrete and to *Engineering Record*, and before I put these magazines away I go through them and make out a card for all articles which I think might be of use to me in the future. Following is a sample card:

I also make out cards for my catalogs, trade literature, etc. I keep such material in letter or magazine files and, on the card I put the number of the file in which it is to be found.

---

[1] Urbana, Ill.

I use an alphabetical index for the main divisions of the cards and under these I have sub-divisions as, for instance, under "C" appears the sub-heading, "Concrete, Plain and Reinforced." This, in turn, is divided somewhat as follows on 5-division 3-in. x 5-in. guides:



Beams (concrete)

The Economic Design of Concrete "T" Beams

Concrete-Cement Age, May 1914. p 246

A very good article on beam design.

FIG. 2

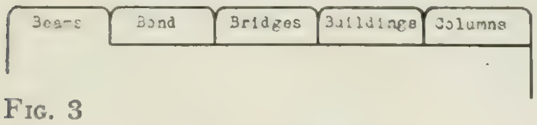


FIG. 3

The two lower left-hand drawers are for 4-in. x 6-in. cards. I use one for specifications, having indexes for the various divisions, such as:

General Conditions, All Contractors.
Masons' Work.
Reinforced Concrete.
Cut Stone Work.
Terra Cotta, etc.

In the other drawer I keep any copied data, notes or other information that is convenient to keep on a 4-in. x 5-in. card.

In the two right-hand drawers I have an envelope system with an alphabetical index in which I keep clippings and articles from papers and magazines which I get from time to time for some special article and do not care to keep the whole magazine.

This system is extremely simple and efficient, for a small collection, at least, and is within reach of all.

The Popularity of Concrete Pipe Is Increasing

A LETTER FROM CHARLES E. SIMS[1]

The accompanying facts regarding concrete pipe, while not new, will remind readers of CONCRETE of the development of concrete pipe use.

Those interested in the manufacture of sewer and irrigation pipe by machinery can find openings in the West and the margins of profit are good. In going over this state in a car I have been surprised at the quantity of pipe being used, the many uses they are being put to and the prices obtainable. But of all the uses of concrete in Cal., the most extensive is for concrete highways, of which the state is justly proud.

[Following are Mr. Sims's "reminders"]:

CONCRETE SEWER PIPE—PAST AND PRESENT USE

Ninety per cent of Germany's sanitary sewers are concrete.

Milwaukee—City Engr. Poetsch writes: "Milwaukee has over 250 mi. of cement pipe sewers, sizes 6" to 18", in use since 1871. There has never been any failure from sewage or factory wastes passing through them."

The Atlantic Mills at Olneyville put in 3,000′ of 20-in. x 30-in. oval pipe 44 yrs. ago, to carry off the expended dyes from the coloring vats. These dyes are composed of acids, salts, potash, alkalies, etc. The sewer is still in use.

Concrete pipe laid as a sewer in Bay City, Mich., in 1873 and uncovered in 1914 were found to be in first-class condition.

The Universal Portland Cement Co. says there are over 20,000,000′ of concrete sewer pipe now in use.

There are 400 mi. of cement sewer pipe in Brookline, Mass., and Engr. E. J. Fort says they are still putting in concrete for sewers.

Twenty-five years ago the city of Greeley put in a storm water concrete sewer. A few years ago this pipe was officially examined and found in perfect condition, though it drains the worst alkali section in the city.

Butte, Mont., has sanitary sewer system and storm laterals built mainly of concrete which are in excellent condition after 24 yrs. of service.

A 10-in. concrete sewer pipe line was laid on Chapin St., South Bend, Ind., and when removed to make place for a larger sewer a few years ago the pipe were resold, being in perfect condition.

San Francisco has spent over $6,000,000 for sewers since 1905. Larger portion concrete—both sanitary and storm.

Los Angeles — One sewer line cost $662,000 and many others have been built of concrete.

Kansas City, Mo., has used thousands of feet of pipe made in a cement pipe plant there.

Over 42 yrs. ago cement sewer pipe were made for Logansport, Ind.

584½ mi. of cement pipe have been made in Philadelphia since 1888, says a statement published in 1908 by the Am. Pipe Mfg. Co., and considerably more than this had been made by the Connecticut Pipe Mfg. Co.

4,000 ft. of 30-in. sewer with laterals 12" diam. were laid in Elkhart, Ind., in 1883 in Second St.

South Bend, Ind., has many cement sewers laid 24 yrs. ago.

Allegheny, Pa., began laying concrete pipe sewers in 1872, of which the records show 13 were laid before 1878. Good today.

Concrete sewers are used almost exclusively in Paris and Vienna and in some places are several hundred years old.

The original Roman aqueducts of the early Roman concrete still carry water to Rome.

Reinforced concrete pressure pipe are in extensive use, 200 mi. of them at least, in the West.

Nearly 50 mi. of concrete sewers had been laid in Oshkosh, Wis., prior to 1908. Some now over 30 yrs. old. Most serviceable.

Cement lined water pipe have been in use in Elizabeth, N. J., for more than 65 yrs. and are still doing the work satisfactorily.

California State Board of Health engineer says: "I have found no evidence to show that sewage or sewer gas has any destructive effect on well made concrete sewers."

Minneapolis, Minn.—Engr. C. Illstrup said: "Have in use 171,000′ of concrete pipe from 20 yrs. to 30 yrs. old. Mostly in good condition. No bad effects from sewage."

Savannah, Ga.—Engr. Rockwell: "Concrete pipe sewers in use 41 yrs. Still giving satisfaction."

Geo. Norton, engr., Buffalo, N. Y., says some oval concrete sewers were laid in that city about 40 yrs. ago. Find them in satisfactory condition.

Patterson, N. J.—Engr. H. J. Harder says: "Concrete pipe sewers in use 39 yrs. I am of the opinion that there is nothing to the claim that acids and gases work an injury to concrete pipe and have never heard the claim made by manufacturers of clay pipe when a concrete pipe of a larger size than is possible to make of clay is under consideration."

City of Chicago has extensive concrete combination sewers seven yrs. old. As good as when completed; no trouble.

Havana, Cuba, spent $15,,000,000 on its new sewer system. The largest pipe were 84-in. concrete.

Albany, N. Y.—Engr. Lanagan says: "Old concrete sewers when dug up were found in good condition."

Richmond, Ind. — Engr. Fred R. Charles: "Sanitary and storm sewers used for a number of years. Both satisfactory."

San Diego, Cal., has put in 30 mi. of concrete sewer.

Salt Lake City has over 10 mi. of concrete sewer 19 yrs. old. Excellent condition.

Springfield, Mass.—Engr. Slocum says concrete pipe used for sewers exclusively up to 1890. Admitted clay because of its low cost. Good opinion indeed of quality of cement pipe made today.

Albuquerque used concrete great deal in sewers. Satisfactory.

Kalamazoo, Mich.—Concrete sewer pipe in use 30 yrs. O. K.

Louisville, Ky., used concrete sewer pipe 5 yrs. and putting in more. Expect to continue its use.

Indianapolis has had satisfaction in the use of concrete, neither acids or gases affecting the pipe.

Ventura and Long Beach, Cal., have concrete storm sewers. Phoenix, Ariz., Hollywood, Cal., Monrovia, Cal., Hillsboro, Ore., Spokane, Wn., Portland, Ore., and many, many other cities have concrete storm and other sewers.

New Bedford, Mass., has its outfall sewer at tidewater, where it is subject to sewage and sea water and to the action of frost.

5,000 mi. of cement pipe are in use in Southern California for irrigation purposes. Over $10,000,000 worth of cement pipe are in use in the upper Mississippi Valley for drainage purposes.

Dense concrete pipe are permanent—the modern pipe.

A recent act by the State of Pennsylvania provides that any person or corporation which has failed to comply with laws for the prevention of spreading of fire or is guilty of arson or willful carelessness shall, in addition to other penalties provided, pay to the city the cost of extinguishing or attempting to extinguish the fire.

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[1] Cons. engr., Pasadena, Cal.

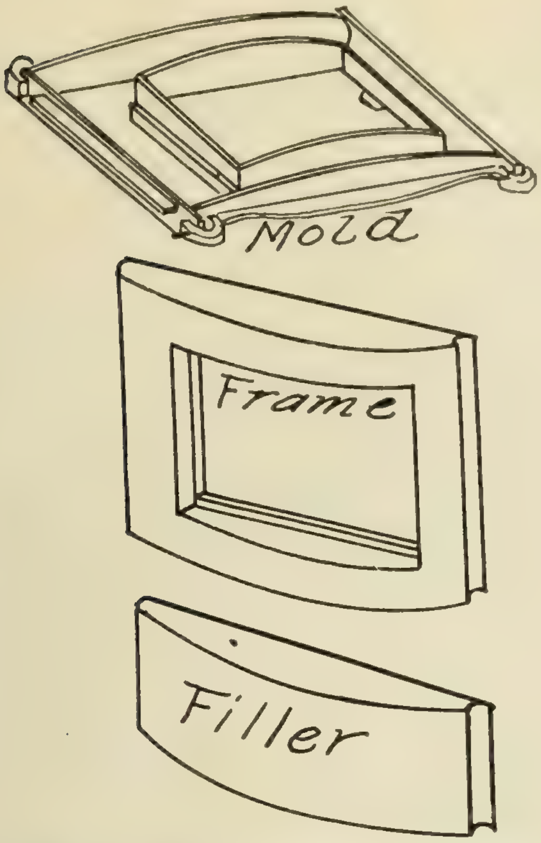

Fig. 8—Typical Concrete Door Frame for Stave Silos

Building Concrete Silos

(Continued from p. 6)

It will be noted that some staves are so arranged as to bring all vertical joints in a straight line, but breaking joints horizontally. This arrangement allows the use of a flat stave which can be adjusted to any angle.

Other types interlock both vertically and horizontally, which necessitates the stave approximating closely the circle to which it is laid.

Joints—Some stave manufacturers join the units by grout or mortar, others depend on a close fitting stave made air-tight by means of a cement wash applied to the interior.

Doors—Separate doors are generally used, though by means of special steel door frames continuous doors can be used. The door frames are usually cast of concrete arranged to engage with the staves, as suggested by Fig. 8.

Permanence—While the stave silo seems a less permanent type than the block or the monolithic, owing to its exposed hoops, it is infinitely better than the wood silo, and its advantages of ease in making, transporting and erecting, and the consequent low price, make it popular. The question has been raised as to the action of fire on the silo, with particular reference to the exposed hoops. Fig. 9 shows a stave silo that successfully withstood a fire which destroyed the barn and silo roof and doors; it is a strong endorsement for this type of structure.

The claim of some advocates of the stave silo, that the lighter wall makes it less likely to chill the silage and thus prevent spoilage, should not be taken too seriously. Any tightly built concrete silo, using good materials and workmanship, will preserve silage perfectly.

SPECIAL SILO UNITS

There are several silo units which, though usually classed as block, really occupy a middle ground between the block and the stave. These units are thicker than the stave, but are not hollow and are usually of considerably larger face area than the hollow block. They are made with edges shaped to retain mortar in such a way as to insure a perfect joint, but the reinforcement is secured by means of rods cast in the unit and coupled as laid. This type has been largely used and is generally laid in thin mortar or grouted, and the depressions left for coupling the reinforcement are pointed. It is quickly placed and the reinforcement is embedded and protected by the concrete (Fig. 10).

A still newer form of silo uses large panel slabs, grooved for horizontal reinforcement and united by vertical ribs cast by means of forms clamped to the panel slabs, which securely join the panels and provide a vertical reinforcement (Fig. 11).

ESTIMATING UNIT SILOS

Most contractors determine a base price for their work per ft. in height of a given size. This base price is determined by local conditions, such as cost of labor and materials, distance of the average move, efficiency of plant, etc. From this base price the price of each silo is determined after a consideration of conditions.

Often the farmer wishes to put in the foundation, or perhaps furnish the gravel and haul cement, and let the contractors put in the foundation. The owner will generally haul block and equipment; if not, haulage must be charged. The owner will often board the help or furnish some labor, scaffolding, etc.

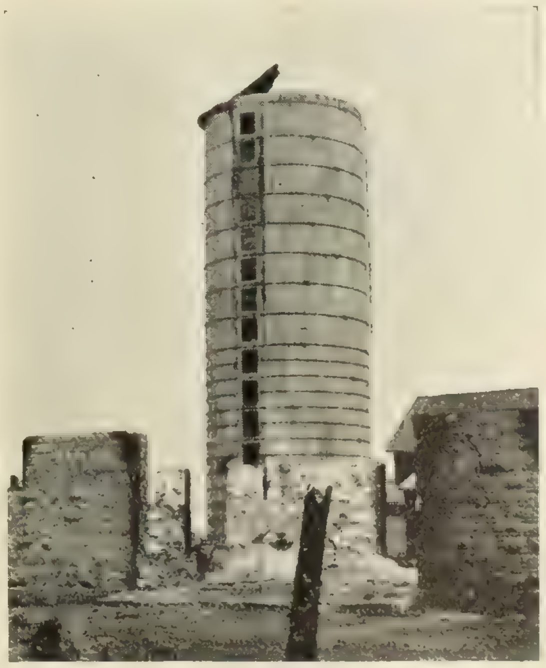

Fig. 11—A Stave Silo That Stood a Fire Test

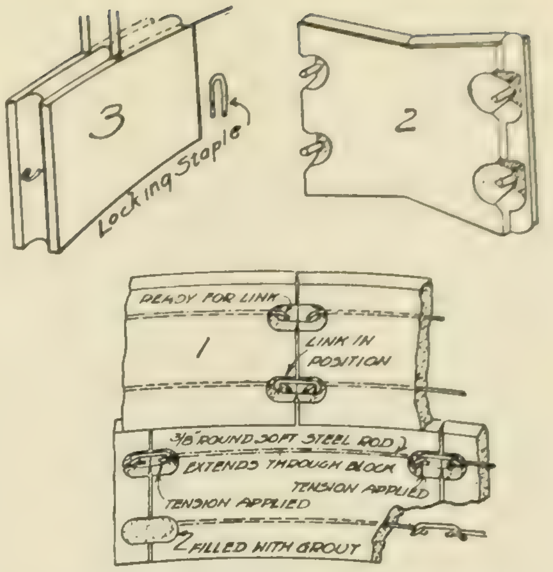

Fig. 10—A Group of Thin Block Containing Reinforcing to be Locked as Laid

1—The Hurst[14]. Locked by links as shown

2—Keystone[15]. Locked in a similar manner and by tongue and groove joint

3—Miller[16]. Locked by staples engaging loops, concave ends grouted

Customers have their own ideas as to details, such as doors, roofs, etc. If they want fancy equipment after talking over the job, let them have it and charge accordingly. The safe way is to determine by experience a base foot price and then add and deduct as circumstances dictate.

To determine the base price, it is an easy matter to figure the number of units for a given silo and their cost at the factory. The foundation cost is at best a guess based on the builder's knowledge of similar work, and the design of the underground work. Do not overlook concrete floor and drain if needed or wanted. Figure haulage on a basis of average distance, to be varied for each job.

Reinforcing can be figured almost exactly. Determine the type of scaffold to be used and charge haulage and waste if necessary.

Decide on a standard style and per ft. cost of door, to be varied for other details. Figure labor of laying and materials for mortar, grout, etc. Add price of standard roof.

Do not overlook items that do not so readily appear, such as depreciation of equipment, time spent in figuring and selling, advertising and liability insurance,—insurance should always be carried, as in many states now an accident can easily ruin an uninsured contractor.

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[14] The Hurst Silo Co., Chicago, Ill.

[15] Keystone Silo Co., Sheffield, Ia.

[16] A. D. Miller, Goshen, Ind.

The following examples of costs are suggestive:

COST OF CONCRETE BLOCK SILOS

CONCRETE BLOCK SILO NO. 1 ON THE FARM OF A. ARMANN, MARTEL, NEBR.[17]

Diameter 16', height 32', 12-in. wall, concrete block, without roof and chute. Block made on site in home-made machine. Capacity 130 tons

Labor—		
26 das., @ $2.00	$52.00	
28 das., @ 2.00	56.00	
3 das., @ 2.00	6.00	
25 das., @ 1.25	31.00	
19½ das., @ 1.25	24.25	
12½ das., @ 3.00 (mason)	37.50	$209.75
Material—		
2 cars sand 1 80,000 1 60,000 @ 6 cts. per 100 lbs. (3,000 lbs. left)	84.00	
248 sacks cement, @ 40 cts.	99.20	
200 lbs. No. 14 galv. wire, @ 6 cts.	12.00	
Blacksmith bill	8.55	
Doors	1.60	205.35
Total cost		$415.10
Cost less home labor		$242.85
Cost per ton		3.19
Cost per ton, less home labor		1.87

[The 12-in. block used was obviously unnecessarily heavy and the cost proportionally high—EDITORS]

NO. 2—R. B. SCHNEIDER'S, FREMONT, NEBR.[17]

Diameter 16', height 37' 6", capacity 167 tons. Two-piece concrete block, with concrete roof, but without chute

Foundation and floor—		
54½ sacks cement, @ 35 cts.	$ 19.08	
12 cu. yds. sand, @ $1.41	16.92	
Labor	9.27	$ 45.27
Block—		
243.5 sacks cement, @ 35 cts.	85.22	
40 cu. yds. sand, @ $1.41	56.40	
Labor on block	101.12	
Hauling block to silo	12.00	254.74
Doors and frames—		
Steel door frame	34.00	
Lumber	6.25	
Tar paper	.50	
Nails	.25	
Bolts	.25	
Carpenter	3.50	44.75
Cornice block—		
7¾ sacks cement, @ 35 cts.	2.71	
1 cu. yd. sand, @ $1.41	1.41	
Labor	3.46	7.58
Erecting silo walls—		
62 sacks cement, @ 35 cts.	21.70	
6 bbls. lime, @ $1.25	7.50	
4 cu. yds. sand, @ $1.41	5.64	
500 lbs. No. 3 wire, @ .027 cts.	13.50	
50 lbs. No. 9 wire, @ .03 cts.	1.50	
Mason's labor	156.00	
Common labor	75.79	281.63
Roof—		
30 sq. yds. metal lath, @ 10 cts.	3.00	
24 sacks cement, @ 35 cts.	8.40	
2¼ cu. yds. sand, @ $1.41	3.18	
1 barn sash	.75	
Labor	9.48	24.81
Total cost		$658.78
Cost less home labor		$414.16
Cost per ton capacity		3.94
Cost per ton capacity, less home labor.		2.66

NO. 2—R. B. SCHNEIDER'S, FREMONT, NEBR. SECOND SILO[17]

Same specifications as first silo

Foundation and floor		$ 45.27
Block		254.74
Doors and frames		44.75
Cornice block		7.58
Erecting walls—		
64½ sacks cement, @ 35 cts.	$ 22.58	
6 bbls. lime, @ $1.25	7.50	
4 cu. yds. sand, @ $1.41	5.64	
500 lbs. No. 3 wire, @ $0.027.	13.50	
50 lbs. No. 9 wire, @ $0.03	1.50	
Mason's labor	128.40	
Common labor	44.84	223.96
Roof		
30 sq. yds. metal lath, @ 10 cts.	3.00	
26 sacks cement, @ 35 cts.	9.10	
2¼ cu. yds. sand, @ $1.41	3.18	
1 barn sash	.75	
Labor	8.03	24.06
Total cost		$600.36

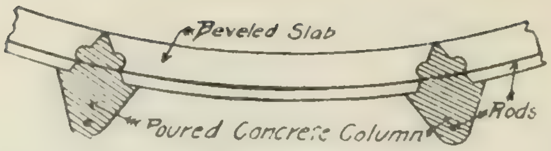

FIG. 11—DETAIL OF CONCRETE PANEL SILO[18]

Cost less home labor	$416.69
Cost per ton capacity	3.59
Cost per ton capacity, less home labor	2.49

Material in the scaffold cost $30, and the labor for erecting and removing in Silos 2 and 3 was $9.48.

Forms for the foundation contained material to the value of $3.92.

NO. 4—E. M. LITTLE, SILVER CREEK, NEBR.[17]

Dimensions—14' 6" x 32' inside; 1,056 block, 24 to course. Double walled, frost, air, and moisture proof. Capacity 107 tons

Foundation—		
Excavating, ½ da.	$ 1.50	
28 sacks cement, @ 42½ cts.	11.90	
Concrete work—3 men 1 da.	4.50	
Reinforcing—old iron and wire	1.00	$ 18.90
Block—		
118 sacks cement, @ 42½ cts.	50.15	
Labor—3 men, 7½ das., @ $1.50	33.75	
4,200 anchors, @ $3.75	15.75	
Rent—mold and pallets	10.00	109.65
Construction—		
Mason, 8½ das., @ $4.00	34.00	
2 helpers, 8½ das., @ $1.50	25.50	
5 sacks cement, @ 42½ cts.	2.13	
3 bbls. lime, @ $1.65	4.95	
200 lbs. No. 4 wire, @ $1.40.	2.80	
¾-in. iron rod for doors	3.00	
24 ¾-in. x 4½-in. bolts	.30	72.68
Boards and roofing for doors		5.25
Total without roof, hauling, and board of help		$206.48
Cost less home labor		$172.48
Cost per ton capacity		1.93
Cost per ton capacity, less home labor		1.61

NO. 5—A. S. CLEARY, NORTH LOUP, NEBR.[17]

Size, 16' x 30'; concrete block made on the farm

Cost of labor and material making the block	$180.00
Labor of mason	95.00
Wire for reinforcing	6.00
Roof	30.00
Doors	20.00
Total	$331.00
Cost per ton capacity	$ 2.78
Cost of concrete block machine	32.00

Chute was built with the barn.

The above is a table compiled from a statement furnished by Mr. Cleary.

NO. 6—E. D. BURGESS, HOUGHTON, N. Y., 1912

10' x 34', 800 block 8" x 10" x 16"
Includes foundation and roof

Gravel and sand haulage only on farm	no cost given
Cement, 40 bbls., including roof and foundation	$ 50.00
Door frames reinforcing	55.00
Incidentals	5.00
Mason	15.00
Home labor	cost not given
Total cash outlay	$125.00

NO. 7—JAS. DRIVER, OWNER, DARLINGTON, WIS.[19]

16' in diameter

Foundation rock quarried on farm 11' high @ $11 per ft.	$121.00
Contractor furnished and laid 22' hollow block @ $8 per ft., paying freight on block 30 mi.	176.00

Note excessive comparative cost of rock masonry, also that cost of rock would increase as silo grew higher.

NO. 8—ELMER FOX, COBB, WIS.[19]

12' x 25' over foundation

Foundation 6' high cost owner	$ 25.00	
Cost of block and mason, 5 das	$180.00	
Two tenders, 5 das.	18.00	
Sand and lime	6.00	
		$204.00

Contract price of block in wall, $7.06 per ft.

Conical wood roof with ruberoid roofing costs $25 to $30

Roof shingled or iron covered, $40

NO. 9[20]

16' x 40' single block wall

Foundation	$ 25.00	
Block mix 4:1 cost 7 cts each.	103.32	
Rods	12.00	
		$140.32
Labor, 4½ das. laying block, mason @ $4.00	18.00	
4 laborers @ $2.00	36.00	
		54.00
Mortar		8.00
Concrete roof—material and labor		30.00
8 doors		42.50
		$274.82

These costs are net to contractors; do not include overhead insurance, cartage or profit.

The following selling prices for block silos erected complete, except roof, as shown at 3, Fig. 10, are quoted by the makers:[21]

Diameter	8'	10'	12'	14'	16'	18'
Price per ft.	$7.00	8.40	9.25	10.00	10.50	11.25

The costs below are based on prices as follows: Cement $1.50 per bbl., sand $1.50 per yd., common labor $2.00 per da., iron $0.03 per lb. The mixture was a 1:4; 6½ sacks cement and 1 yd. of sand make about 100 staves.

NO. 1[22]

16' x 30', 125 tons

1,163 staves 12" x 26", @ 6 cts.	$69.78	
11 door frames, @ $1.00	11.00	
11 doors, @ $1.00	11.00	
1,224 ft. ⅝-in. hoop iron	36.72	
64 lugs and nuts, @ 5 cts.	3.20	
2 angle irons, 2" x 30"	5.70	
12 pieces, 2" x ¼", iron	2.10	
4 bbls. cement	6.00	
		$145.50
Cost of erection		25.00
		$170.50
Foundation (estimated)		25.00
		$195.50
Cost per ton		$1.55
Cost of above foundation per ft. without roof		$5.68

These are net costs to contractor. This silo should sell for $10.50 per ft.

NO. 2[22]

20' x 40', 292 tons

2,048 staves 12" x 26", @ 6 cts.	$122.88	
15 door frames, @ $1.00	15.00	
15 doors, @ $1.00	15.00	
2,140 ⅜-in. iron hoops	64.20	
112 lugs and nuts, @ 5 cts.	5.60	
2 angle irons, 2" x 40"	7.68	
17 pieces, 2" x ¼"	3.05	
6 bbls. cement	9.00	
		$242.41
Cost of erection		40.00
		$282.41
Foundation (estimated)		25.00
		$307.41
Cost per ton		$1.05
Cost per ft. in height above foundation		7.06

This is net cost to contractor, should sell at $12 to $13 per ft. Above prices do not include roof, add $20 to $45.

Below is a retail price list issued by one stave silo manufacturer.[23]

This price includes staves, hoops, steel door frames and doors, erection and under ordinary conditions the foundation and hauling.

It does not include roof and is subject to special conditions, but it does carry builder's profit.

DEALERS' RETAIL PRICE LIST

Size	Tonnage	Price	Staves	Half Staves	Door Frames
10 x 28	42	$225	374	68	11
12 x 28	65	270	462	84	11
12 x 35	100	345	588	84	14
14 x 28	85	300	528	96	11
14 x 35	125	375	672	96	14
14 x 40	155	430	768	96	16
16 x 35	145	425	784	112	14
16 x 40	175	485	896	112	16
18 x 35	185	470	896	128	14
18 x 40	215	545	1024	128	16
20 x 40	265	600	1152	144	16

TANKS

Height	Diam.	Price
2 ft. 4 in. x	6 ft.	$12.00
2 ft. 4 in. x	8 ft.	18.00
2 ft. 4 in. x	10 ft.	25.00
2 ft. 4 in. x	12 ft.	33.00
2 ft. 4 in. x	14 ft.	42.00
2 ft. 4 in. x	16 ft.	52.00

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[17] From Bul. 138, Nebr. Exp. Sta.

[18] Concrete Panel Silo Co., Kansas City, Mo.

[19] Loren W. Loy, Contractor, Wis., in *Concrete*, Jan., 1910, p. 48

[20] Courtesy Kenney-Hoflund Co., Hawarden, Ia.

[21] Courtesy A. D. Miller, Goshen, Ind.

[22] Courtesy Ellipse Stave Silo Co., Kansas City, Mo.

[23] Interlocking Cement Stave Silo Co., Des Moines, Ia.

The 1915 Practice of Prominent Builders of Concrete Roads

(Staff Article)

The present practice in concrete road construction as revealed in letters from prominent road builders, is shown to be progressive and interesting in many particulars. The most radical changes are with respect to joints while the materials used are more carefully selected.

AS TO THE JOINTS

A. R. Hirst, State Highway Engr., Wisconsin, writes:

> Space between expansion joints, both 1914 and 1915, is 50′. We started to stop the use of metal plates at expansion joints in 1914, and have almost entirely discontinued the practice in 1915. The joints are now filled with an expansion strip furnished in sheets and without the metal protecting device. I seriously doubt whether we will ever increase the distance between expansion joints to more than 50′. The elimination of metal plates at expansion joints at a spacing of 50′ has meant an average saving of about 2 cts. per sq. yd.

H. G. Shirley, Chief Engr., State Roads Comm., Maryland, writes:

> Last year we made expansion joints 60′ apart but this year we are not using any except where work is stopped for a period of 20 mins. or longer.
>
> We find that closing down for lunch, delays, etc., make an average space between joints of from 100′ to 150′. This work shows up very well and the cracks are fairly regular across the road—24′ to 40′ apart. There was no buckling or jumping on any of the jobs. On these joints we are requiring the use of the split float. We still use tar paper between the joints and if the joint breaks, bituminous material is poured in.

H. J. Kuelling, Highway Commr., Milwaukee Co., Wis., writes:

> A marked departure has been made in expansion joints, about three-fifths of the work now being put in having no protection plates. We are expecting to do away with them entirely, as most of the joints are tarred before winter, whether protected by plates or not, in order to waterproof them. So the main advantage of the plates, that of protection, is lost. The joints, whether protected or not, are filled with felt, impregnated with asphalt or tar, coming flush with the concrete in the case of protected joints and about one-half inch above in the case of unprotected joints. The object of leaving the felt extend above the concrete is to seal the joint by filling the crease, which is made by rounding the edge of the concrete next to the joint to a ¼-in. radius. The concrete on each side of the felt is brought to grade by means of a double wooden float (the split float), thus insuring both sides being of the same elevation. All joints are being placed 50′ apart and are ¼″ thick.

H. E. Breed, First Deputy Commr., N. Y. Comm. of Highways, writes:

> Expansion joints are spaced at 30-ft. intervals, ⅜″ wide. We have tried armored joints, yellow pine plank and tar paper, and have found that the yellow pine plank and in some cases oak plank have given us the best results. Better protection to the edges of the concrete is obtained by setting the plank a little high, allowing the traffic to broom the edge. By so doing, the wood being high, there is no impact on the edge of the concrete of the joint to cause it to spall.

Edward N. Hines, Board of County Road Commrs., Wayne Co., Mich., writes that metal protection plates are still being used at joints, separated by ¼″ of asphalt felt. In other respects Wayne Co. work is following close to the practice which has already proved so satisfactory.

AS TO AGGREGATE MIXING AND PLACING

From Mr. Breed comes this as to N. Y. state materials, mixture and placing:

> During 1914 all our concrete roads were built of plain concrete of the 1:1½:3 mix. This year we are building with the same proportions, but some reinforcing is being tried where this pavement goes over clay sub-soil.
>
> New specifications were adopted Sept. 15, 1914, and the concrete roads being constructed during 1915 are built under these specifications. The sizes of coarse aggregate remain the same but the use of gravel is strictly specified so that it is confined to restricted regions of the state where the best quality of the material is available. The fine aggregate is more definitely specified on gradation and compressive strength.
>
> Last year we used a 7-in. depth at center and 5-in. at the sides. In order to obtain a parabolic section without increasing the quantity of concrete we are not using 6¾″ at center and 4¾″ at the sides. Crown remains the same at ¼″ per ft. The conditions that we have coped with thus far require no reinforcement, except as stated for clay sub-soil.
>
> Thorough spading of the concrete is insisted upon to remove air bubbles, to increase the density and to bring the mortar to the surface. Consolidation of the concrete and the form of the finished surface is obtained by means of heavy screeds which rest upon the side forms and are drawn back and forth over the surface. The screeding is followed by rubbing down with a wooden float, after which the surface is roughened by brooming. When initial set has taken place, the surface is covered with sand to a depth of one inch or with the material composing the shoulders, and thoroughly dampened morning and night for a period of 10 das.

Mr. Kuelling, in reference to Milwaukee Co. work, writes:

> Our mix remains the same, a 1:2:3½. We are, however, even a little more strict in regard to getting every batch of proper consistency and proportions. On some jobs the workmen are trained to come in rotation. Where three wheelbarrows of stone are used and two of sand in a batch, one wheelbarrow of stone is dumped first, then one of sand, another of stone, another of sand, and the last of stone. By always dumping in this manner, there is little danger of a batch containing too much or too little material. The cement used per sq. yd. is checked each day for every job and a reason demanded if it varies materially from the computed amount. Progress on all jobs is also platted each day the same as last year.
>
> Some new methods of handling material will be tried but are not in use at this date. One job will be placed with a 36-cu. ft. batch mixer, where material will be brought by an industrial track, one batch being placed in each car and all sand, stone and cement loaded at one central point.
>
> Regarding the material, we are trying to realize the importance of the word "well" where it says, "the material shall be well graded both as to sand and coarser aggregate."

Mr. Shirley says of work in Maryland:

> We recently let a contract for something over 4 mi. and called for the use of 10% hydrated lime. Whether or not this will be a benefit has not yet been decided, but I am trying it out on this 4-mi. stretch to see how it works.

COSTS AND ECONOMIES

Contractors and their men who are gaining in both skill and celerity in their work as a result of experience on each new job are doing a great deal to bring the cost down and the quality up. Better materials which cost more are, however, offsetting the lower labor costs, but the result is ultimate economy, for there is probably much more value for the money invested. Better equipment is doing a great deal to give better work at a lower cost. There is a growing interest in industrial railways for conveying materials.

Of work in Wayne Co., Mich., Mr. Hines says that experience with one industrial railway equipment[1] last year has led to the use of two this year. Wayne Co. is also developing and perfecting, by application on present road work, a power-operated pavement finishing machine.[2] So far this has not proved remarkable from cost results over hand finishing but there is great promise of a quality in finishing, giving the best possible surface with minimum working of the surface, which seems ideal for durable results. The machine consists of a series of finishing

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[1] Orenstein-Arthur Koppel Co., Koppel, Pa.

[2] R. D. Baker Co., Detroit

AVERAGE COST OF CONCRETE ROADS (1914)

State	Labor	Teaming	Mech. Equip.	Materials	Misc.	Total	Number Sq. Yds.
Connecticut	$0.181	$0.142	$0.046	$0.752	$0.010	$1.088	200,066
Florida	0.108	0.028	0.003	0.838	0.014	0.991	13,000
Indiana	0.134	0.130	0.044	0.777	0.022	1.017	89,794
Illinois	0.136	0.101	0.033	0.528	0.016	0.814	17,970
Iowa	0.213	0.084	0.028	0.789	0.036	1.116	90,364
Kansas	0.396	....	0.026	0.819	0.007	1.248	1,503
Kentucky	0.146	0.214	0.020	0.477	0.018	0.875	4,144
Maryland	0.111	0.128	0.065	0.716	0.057	1.077	36,211
Massachusetts	0.195	0.104	0.039	0.609	....	0.947	26,200
Michigan	0.222	0.032	0.021	0.655	0.050	1.028	92,217
Mississippi	0.261	0.085	0.150	0.642	0.094	1.232	12,031
Missouri	0.209	0.133	0.027	0.656	0.059	1.045	22,376
New Hampshire	0.126	0.097	0.032	0.907	....	1.162	6,066
New Jersey	0.179	0.089	0.016	0.797	....	1.091	8,355
New York	0.156	0.085	0.055	0.666	0.050	1.027	730,982
Ohio	0.181	0.091	0.067	0.642	0.009	0.946	58,968
Pennsylvania	0.279	0.091	0.031	0.742	....	1.269	10,072
Texas	0.316	0.117	0.007	0.668	0.016	1.123	6,642
West Virginia	0.098	....	0.060	0.912	....	1.070	10,045
Wisconsin	0.188	0.110	0.045	0.682	0.023	1.033	61,879
Grand Average	0.183	0.105	0.040	0.719	0.046	1.058	*1,498,883

*Exclusive of profits and overhead charges.

blades or trowels which push the material forward as necessary and press it down firmly.

Mr. Shirley writes of progress in Maryland:

> We have been able to work out certain economies in the handling of the materials, and also have been able to economize by the use of improved machinery, as well as by the use of improved mixers, industrial railways, etc., and also by having a greater number of trained men. The average cost of concrete road construction on work done last year was $1.20 per sq. yd. This year the average cost has been about $1.10 per sq. yd. The bidding at the present time, however, runs close to $1.00 per sq. yd.

Mr. Kuelling reports costs in Milwaukee Co. for 1914 work as varying from $1.08 to $1.45, while the 1915 work will probably vary from $1.02 to $1.25, this lower cost being due to the scarcity of contract work and to cheaper labor and teams.

In New York state, Mr. Breed reports 1914 cost per sq. yd. at $1.05 and for 1915 thus far $1.04.

Mr. Hirst for the state of Wisconsin reports the average sq. yd. cost in 1914 at $1.25, exclusive of grading, draining and culvert work, and says the 1915 average will probably be $1.20 or even less.

State Engr. George W. Cooley, Minnesota, with specifications following very close to the Standards of the Am. Concrete Inst., reports costs for 1914 ranging from $.975 to $1.20.

In addition to these reports as to work in definite localities, it is particularly interesting to get the view of W. A. McIntyre, Chf. Road Engr. of the Assn. of Am. Portland Cement Mfrs., under whom are scores of young engineers engaged in inspection work in many localities. A letter from Mr. McIntyre is quoted in part as follows:

> Our work on road inspection this year will be along similar lines to that of last year, with the exception that the inspection will be intermittent, rather than continuous, as given last year. In 1914, the U. S. and Canada were divided into seven districts with the Division Engineer and road assistants for each district. In 1915, the U. S. and Canada were divided into 17 districts, with the Division Engineer and road assistants in each district. There is a general tendency toward better specifications and workmanship this year; on account of our inspection work last year, the requests for inspectors have been so large that we are offering to see that the work is started off properly and to keep in touch with it during construction.
>
> The specifications for aggregate are practically the same as those of last year. There are a few changes, as follows: 1914 specifications for fine aggregate stated that not more than 20% shall pass a sieve having 50 meshes per lin. in. and not more than 5% shall pass a sieve having 100 meshes per lin. in. The 1915 specifications state, not more than 25% shall pass a sieve having 50 meshes per lin. in. and not more than 5% shall pass a sieve having 100 meshes per lin. in. The specifications for coarse aggregate are practically the same as for 1914, with the exception that coarse aggregate shall be such as to pass a 1½-in. round opening and shall range from 1½" down, not more than 5% passing a screen having four meshes per lin. in. and no intermediate sizes shall be removed. The proportions for one-course work in 1915 specifications are the same as those for 1914 work. In the two-course type of construction there is a slight difference in the proportions for the wearing course. The 1915 specifications state as follows:
>
>> *No. 1 Aggregate for Wearing Course*—No. 1 aggregate for the wearing course shall consist of clean, hard, tough, durable, crushed rock or gravel, free from vegetable matter, and shall contain no soft, flat or elongated particles. It shall pass, when dry, a screen having ½-in. openings, and not more than 10% shall pass a screen having ¼-in. openings.
>>
>> *No. 2 Aggregate for Wearing Course*—No. 2 aggregate for the wearing course shall consist of clean, hard, tough, durable, crushed rock or gravel graded in size, free from vegetable or other deleterious matter, and shall contain no soft, flat or elongated particles. The size of No. 2 coarse aggregate shall be such as to pass a 1-in. round opening and shall range from 1" down, not more than 5% passing a screen having four meshes per lin. in. and no intermediate sizes shall be removed.
>>
>> *Proportions for Mixture No. 1*—The concrete for the wearing surface shall be mixed in the manner hereinbefore specified in the proportions of one bag of cement to not more than 1½ cu. ft. of "No. 1 Aggregate for Wearing Course," and in no case shall the volume of the fine aggregate be less than ½ the volume of the "No. 1 Aggregate for Wearing Course."
>>
>> *Proportions for Mixture No. 2*—The concrete for the wearing course shall be mixed in the manner hereinbefore specified in the proportions of one bag of Portland cement to not more than 1½ cu. ft. of fine aggregate, and not more than 2½ cu. ft. of "No. 2 Aggregate for Wearing Course," hereinbefore specified, and in no case shall the volume of the fine aggregate be less than ½ the volume of "No. 2 Aggregate for Wearing Course."
>
> Whereas, the 1914 specifications state:
>
>> The aggregate for the wearing course shall consist of a mixture of 2 parts of the material specified under "Fine Aggregate" and 3 parts of clean, hard, durable, crushed rock or gravel, free from dust, soft particles, loam, vegetable or other deleterious matter, and passing when dry a screen having ½-in. openings and retained on a screen having ¼-in. openings.
>>
>> *Proportions*—The mortar for the wearing course shall be mixed in the manner hereinbefore specified in the proportion of one sack of Portland cement and not more than 2 cu. ft. of "Aggregate for Wearing Course," hereinbefore specified.
>
> The thickness and crown are the same as that recommended for 1914, that is, a minimum thickness of 6" at sides and 1/100 (one one-hundredth) of the width of the road with a flat sub-grade up to 20′ in width. Instead of spacing joints 25′ to 30′ apart, the new specifications limit the distance to a maximum of 36′.
>
> The expansion joint space is specified as ¼", whereas last year's specifications stated a variation from ¼" to ⅜". The joint filler is specified as a prepared strip of fiber matrix and bitumen or other similar material of approved quality; the use of the poured joint is not recommended. Where the metal protection plates are used, the joint filler is to conform to the crown of the road. The concrete adjacent to the metal protection plates is to be floated 6" on each side of the joint with a steel float in order to produce a dense surface. Where the unprotected joints are used, the width of the joint filler is to be ½" greater than the depth of the pavement. The concrete adjacent to the joint filler is to be finished with a divided wood float which permits the finishing to be done at the same grade on both sides. Before the road is thrown open to traffic, this filler is to be cut off approximately ¼" above the surface.
>
> The use of an economical finishing machine to produce a more durable and uniform grade and appearance is recommended. We have found that a heavy template produces the best results. We have also learned that the use of canvas to protect the surface from the direct rays of the sun and high wind, as well as from sudden rainfall, is decidedly advantageous. It has been found that wetting of the fine and coarse aggregate in hot weather, and wetting at all times, coarse aggregate that has a high percentage of absorption will prevent checking of the surface. The specifications for curing and protection are the same for 1914 and 1915.
>
> We have not worked out any new economies for handling construction work, but the information gathered last year, when applied to the 1915 work, will produce a more durable pavement.
>
> The cost of concrete road construction based on 8,000,000 sq. yds. of which we have cost data, averages $1.27 per sq. yd. for 1914; based on 10,000,000 sq. yds., prior to 1914, the cost was $1.25 per sq. yd. We have not sufficient cost data on the 1915 work to warrant a statement on this, but there is no reason to believe that the cost will exceed that of previous years.

In addition to the above, it might be well to note some of the following information gathered from our 1914 work:

We have found that it is necessary to have tests made on sand before advancing an opinion on the sand, and the use of screenings is not recommended without testing them. The use of metal protection plates is not necessary where the joints are properly made and maintained. Experience has shown that the joint filler should be perpendicular to the surface and the use of a rigid joint filler to insure this perpendicularity is preferable; better results are obtained when the filler is in sections at least one-half the width of the road and preferably the length should be that of the width of the road. We have also found that it is necessary that reinforcement be placed on roads 20′ or more in width and on narrow roads where there is doubt of drainage and stability of sub-base.

The accompanying tabulated data of costs in concrete road construction are worked out from statistics gathered and compiled by the Assn. of Am. Portland Cement Mfrs. The figures are based upon a large number of roads built in various parts of the country, and cover a total of about 1,500,000 sq. yards. No account is taken of sub-grade or any item not included in the construction of the actual road surface. The cost table is from *Engineering Record.*

Standard Form for Tabulation of Cost Data

State of....................Contract No......... ....to....................Co.
Work Began or Completed............Began or Finished Concrete..............Working Days
Cross Section 4¾ in.-6¾ in.-4¾ in.-16 ft. wide. Contractor..............................
Equipment 10 Ton Roller (......)..........Traction Engines.................Wheel Scrapers
..............Scarifier 1-2 H. P. Pump..........Sand Washing Plant Capacity.................
1 Hoist 2 Stone Trucks

Daily Report—Sept. 7, 1914. ....Road Ass't.

Labor	No. Hrs.	Wages per Hour	Total Cost	Total Amount Handled	Cost per Cu. Yd.	Sq. Yd. Cost per Pavem't
On Sand at Pit or Washer..............	..					
On Sand at Work	3⅓	.....	5.00	49 cu. yd.	$0.102	$0.0069
On Stone at Cars or Quarry	6⅔	.....	10.00	99 cu. yd.	0.102	0.0138
On Stone at Work	..	.....	....	....	......	......
Wheeling Sand at Job.................	40	$0.175	7.00	49 cu. yd.	......	0.0097
Wheeling Stone at Job	80	0.175	14.00	99 cu. yd.	......	0.0194
On Mixer, Loader	30	0.175	5.25			0.0072
Engineman	10	0.30	3.00			0.0041
Fireman	10	0.20	2.00			0.0028
Chute or Bucket	..	.....	....			0.
Sub Grade before Mixer..............	10	0.175	1.75			0.0024
Sub Grade behind Mixer..............	..	.....	....			0.
Leveling Concrete	20	0.175	3.50			0.0048
Templet Men	20	0.175	3.50	124 cu. yd.		0.0048
Finishing Pavement	20	0.175	3.50	concrete	......	0.0048
Forms, Joints and Reinforcement Men..	20	0.175	3.50			0.0048
Wetting Pavement	5	0.175	0.875			0.0012
Covering New Pavement...............	20	0.175	3.50			0.0048
Superintendent	10	0.750	7.50			0.0103
Watchmen	5	0.175	0.875			0.0012
Timekeeper	10	0.300	3.00			0.0041
Foremen	10	0.400	4.00			0.0055
Waterboy	10	0.150	1.50	......	......	0.0021
Engineman at Sand Washer............	..	.....	....	......	......	.....
Total Labor						$0.1147

Teaming	No. Trips	Cost per Day	Total Cost	Av. Haul or Pump	Amount Hauled or Pumped	Cost per Cu. Yd. Mi. or 1,000 Gal. Mi.	Cost per Cu. Yd. at Job	Amt. per Sq. Yd. Pavement	Cost per Sq. Yd. Pavement
Sand	16	$13.95	....	1,300 ft.	49 cu. yd.	....	....	....	0.0192
Stone, 2 trucks...	33	28.78	....	1,300 ft.	99 cu. yd.	....	....	....	0.0397
Cement, 1 team...	21	18.27	....	1,500 ft.	957 sacks	....	....	....	0.0252
Water	..	6.00	....	....	....	....	....	....	0.0083
Total teaming									$0.0924

Mechanical Equipment	Cost of Plant	Int. & Deprec. of Plant 0.00154 x Cost	Cost of Labor	Cost of Supplies	Cost Sq. Yd. Pavement
Steam Roller	$2,000	$3.08	$3.00	$3.00	$0.0125
Wheel Scraper	.....	....	....	....	......
Scarifier	.....	....	....	....	......
Pumps	600	0.93	3.00	3.00	0.0097
Mixer	1,850	2.85	5.00	....	......
Forms	.....	....	....	....	......
Barrows, Boxes, etc..................	.....	....	....	....	......
Tractor	.....	....	....	....	......
2 Motor Trucks.......................	7,100	11.13	6.00	6.00	0.0319
Sand or Gravel Washing Plant.........	.....	....	....	....	......
Stone Crushing Plant.................	.....	....	....	....	......
1 Hoist	7,000	10.78	7.00	8.00	0.0356
Total mechanical equipment..........					$0.0897

Quantities and cost of materials theoretically required and actually used on 410 lin. ft. 725 sq. yd. of above road. Barrel of cement = 3.8 cu. ft.

			Per Unit Cost	Average Haul	Total Cost at Job Excl. of Haul	Cost per Sq. Yd. of Pavement
Theoretical:						
Cement	237	bbls.	$1.15 F.O.B. Cars	at job		
Sand	49	cu. yd.	1.63 F.O.B. Cars 0.77 cu. yd. Pit	at job		
Stone or gravel........	99	cu. yd.	1.85 F.O.B. Cars 0.70 cu. yd. Pit	at job		
Actual:						
Cement	239.2	bbls.		1,500	$275.08	$0.379
Sand	50	cu. yd.		1,300	81.50	0.112
Stone or gravel........	101	cu. yd.		1,300	186.85	0.258
Steel or wooden joints....	224	lin. ft.			10.08	0.014
				Total materials		$0.763
				Grand total		$1.0598

Notes:

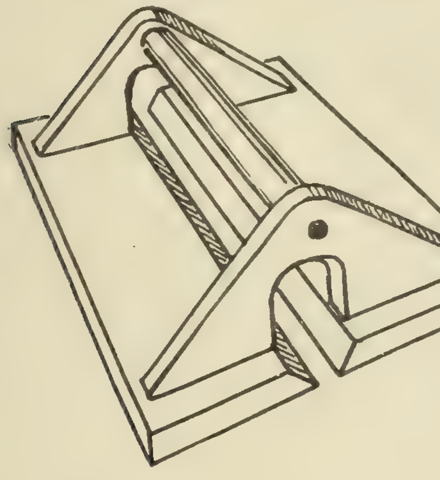
The above report is taken as an average for the last seven working days: 410 lin. ft. per da., or 725 sq. yd. of pavement.

Amount of water used cannot be determined.

Hauling of materials by two motor trucks and one wagon.

Cost of hoist is estimated.

The Split Float for Finishing Road Joints



The Split Float

The new standard specifications for concrete roads and pavements of the Am. Concrete Inst. provide for the use of a wood float, so divided that both sides of unprotected joints may be finished at one time to insure a true surface. The joint filler, of the kind prepared in strips, projects above the pavement surface and without the "split float" it is almost impossible to keep the concrete on both sides, in the same plane.

Slate, asbestos, cement and tin roofs should find a much broader market in Massachusetts than has hitherto existed. According to the report of the committee appointed to consider the matter of combustible roof coverings in the Bay State, it is recommended that every municipality in the district shall pass an ordinance requiring the use of fireproof covering on all roofs and dormer window tops. Fire Prevention Commr. O'Keefe is to communicate this recommendation to every city and town in the district. The finding of the committee is the outcome of an extended investigation which decided in favor of fireproof roofs over the wooden shingles now so largely used throughout the New England states. This regulation is already in force in Salem.

Organizations

American Concrete Institute, Charles L. Fish, Secretary, Harrison Building, Philadelphia, Pa.

American Concrete Pipe Association, Secretary, E. S. Hanson, 538 S. Clark St., Chicago.

American Highway Association, I. S. Pennybacker, Jr., Executive Secretary; Colorado Bldg., Washington, D. C.

American Road Builders' Association, Secretary, E. L. Powers, 150 Nassau St., N. Y. C.

Association of American Portland Cement Manufacturers, Percy H. Wilson, Secretary, Bellevue Court Building, Philadelphia, Pa.

Cement Products Exhibition Co., 208 S. LaSalle St., Chicago, Ill.; Robt. F. Hall, Secy., Chicago Cement Show, Coliseum and Light Infantry Armory, Feb. 12-19, 1916.

Iowa Association of Cement Users, Secretary, H. H. Dean, Glenwood, Ia.

Mid West Cement Users' Association, Secy.-Treas., Frank Whipperman, Omaha, Neb.

Pan-American Road Congress, Oakland, Cal., Sept. 13-17, 1915; Gov. George W. Gates, Vermont, Chmn. Ex. Com.

The Pan-American Road Congress

The Executive Committee of the Pan-American Road Congress provides that there shall be two classes of members of the Congress, to be known as donor and temporary. Donor members will be those who pay not less than $50, and temporary members will be individuals who pay a fee of $2.00. Both donor and temporary members will be entitled to participate in the proceedings of the Congress and receive copies of the printed Proceedings to be issued thereafter, without additional cost. All members in good standing of both the American Road Builders' Assn. and the American Highway Assn., as of June 1, 1915, will have all the rights and privileges of temporary members, and will be entitled to a copy of the Proceedings without cost. Donor members, in addition to the publication of their names in the advance and the final programme, will be entitled to the nomination of one temporary member for every $10 subscribed by them, such temporary members to be accorded the same privileges and receive the publications as other temporary members. As already announced, the Pan-American Road Congress will be held in Oakland, Cal., Sept. 13-17, 1915. The plans for holding this Congress are in the hands of an Executive Committee, composed of Gov. Charles W. Gates, Vt., Chairman; W. W. Crosby, former State Highway Engr. of Md.; James H. MacDonald, former State Highway Commr. of Conn.; J. E. Pennybacker, Chief, Division of Economics, U. S. Office of Public Roads, and E. L. Powers, Editor of *Good Roads*. Charles P. Light, formerly field secretary of the Am. Highway Assn., is now with the Pan-American Road Congress organization.

It is not unlooked for nor unhoped for that the present affiliation of the two highway organizations may result in permanent amalgamation. One of the chief difficulties in the way of amalgamation heretofore has been over the mere matter of a name.

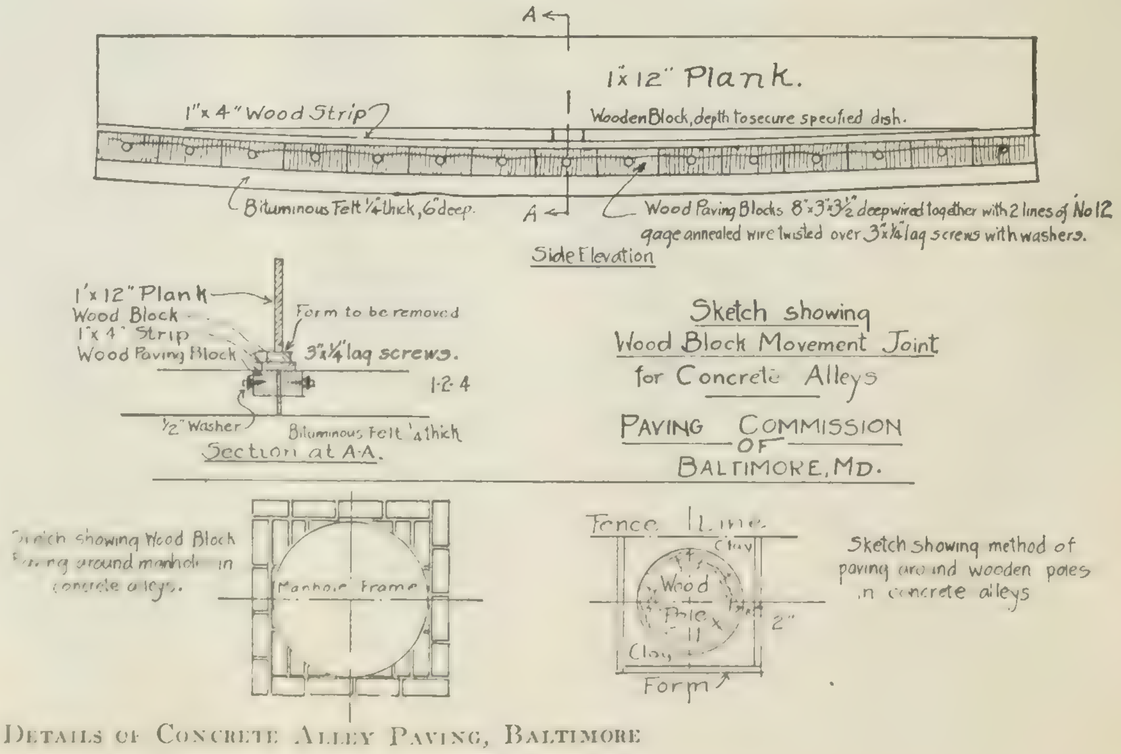
Annual Meeting of The Concrete Institute

At the sixth annual general meeting of the Concrete Institute, England, officers were elected as follows: R. H. Harry Stanger, Assoc. M. Inst. C. E., A. M. I. Mech. E., M. Iron and Steel Inst., F. C. S., M. Am. Soc. Test. Mat.; D. B. Butler, Assoc. M. Inst. C. E., F. G. S.; Dr. J. S. Owens, B. A., M. D., Assoc. M. Inst. C. E., M. R. San. I., F. R. G. S., F. G. S.; W. G. Perkins, District Surveyor for Holborn; Ewart S. Andrews, B. Sc. (Lond.); J. Ernest Franck, A. R. I. B. A., M. R. San. I.; Lewis H. Rugg, Assoc. M. Inst. C. E., Past Chairman J. I. E.; G. C. Workman, M. S. E.; J. S. E. De Vesian, M. Inst. C. E., M. I. Mech. E.

"We have stood solidly for the concrete silo as against the wooden silo, and the experience of the state justifies our stand."—G. E. Morton, Colorado Agr. Coll., Fort Collins, Col.

Concrete Alley Paving with Wood Block Joints in Baltimore

The accompanying detail shows an interesting design of concrete alley pavement with wood block joints now in extensive use in Baltimore. In 1914 a total of 5,662.40 lin. ft. were put down, equalling 10,108.62 sq. yds. Up to the end of June this year 5,608 lin. ft. or 9,322.29 sq. yds. have been laid. These "pavements are being constructed at a cost per sq. yd. of about $1.00 less than vitrified block on a 4-in. concrete base," writes R. M. Cooksey, Prin. Asst. Engr. of the Paving Comm. "We have not experienced any cracking in these alleys, although they have passed through one winter, but I do not think it fair expressing an opinion at this time as to just what kind of surface this pavement is going to give us."


A
1"x 12" Plank.
1"x 4" Wood Strip
Wooden Block, depth to secure specified dish.
Bituminous Felt ¼" thick, 6" deep.
A
Wood Paving Blocks 8"x 3"x 3½" deep wired together with 2 lines of No 12 gage annealed wire twisted over 3"x ¼" lag screws with washers.
Side Elevation
1"x 12" Plank
Wood Block
1"x 4" Strip
Wood Paving Block
Form to be removed
3"x ¼" lag screws.
1·2·4
½" Washer
Bituminous Felt ¼" thick
Section at A-A.
Sketch showing Wood Block Movement Joint for Concrete Alleys
PAVING COMMISSION OF BALTIMORE, MD.
Sketch showing Wood Block paving around manhole in concrete alleys.
Manhole Frame
Fence Line
Clay
Wood Pole
2"
Clay
Form
Sketch showing method of paving around wooden poles in concrete alleys

Details of Concrete Alley Paving, Baltimore

Eighteenth Annual Convention of the American Society for Testing Materials

The 18th annual meeting of the Am. Soc. for Test. Mat. was held at Atlantic City June 22 to 26, with about 600 in attendance. The headquarters was the Traymore Hotel, a newly erected concrete edifice said to be the largest of its kind in the world.

The principal business of the first day's meeting was the annual report of the Executive committee, which showed an increase in membership for the year of 155 as against 113 for the previous year, the total membership of the Society being, as stated by the secretary, 1,862. A number of amendments to the by-laws were submitted, the principal object of which was to provide additional revenue for the Association. These were referred to an adjourned meeting to be held on Wednesday evening after a conference had been had between the outgoing and the incoming Board of Direction. The tellers reported the election of Prof. Mansfield Merriman as pres.; Gen. William H. Bixby, former chf. of engrs., U. S. Army, vice-pres.; Executive committee—James H. Gibboney, cf. chem. of the Norfolk & Western Ry.; Prof. W. K. Hatt, Purdue Univ.; J. A. Mathews, gen. supt. of the Halcomb Steel Co., and Dean Edward Orton, Jr., of Ohio State Univ. Prof. Merriman was one of the original organizers of the American section of the International Assn. for Test. Mat. and was chairman for the first two years of the Society's organization, from June, 1898, to 1900. At a later meeting the secretary reported as the result of the conference on new by-laws that the officers recommended that the dues of members be increased from $10 to $15 per annum and that the dues of junior members should be increased from $5 to $7.50, this increase to take effect Jan. 1, 1915. After a short address by Robert W. Lesley, who was one of the founders of the original organization, and who referred to the growth of the Society from its earliest days to its present position as one of the leading engineering societies of the U. S., the meeting, without further debate, unanimously adopted the recommendations as to increased dues and thus provided ample income for the future requirements of the Society.

The meeting of Thursday afternoon was devoted to papers on cement and concrete. Prof. Talbot of Illinois Univ. presided. The first business was the report of Committee C-1 on Standard Specifications for Cement. In the absence of the Chairman, G. F. Swain, the report was presented by the secretary, Richard L. Humphrey. The report was not completed for publication at this time.

An interesting report was that of Committee C-9, the newly appointed body dealing with Standard Tests of Concrete and Concrete Aggregates. An elaborate program is presented in this report and many of the committees are already at work in the lines of their appointed duties. The report was read by Sanford E. Thompson.

A paper on the "Microstructure of Concrete" was read by Nathan C. Johnson, who for several years has been making microscopic examinations.

THE MICROSTRUCTURE OF CONCRETE

Mr. Johnson presented a preliminary statement of his investigations at the last convention of the Am. Concrete Inst. The present paper gives details at length.

In the investigation of concretes as outlined in this paper, the general nature of concretes and the causes of disintegrations are studied and determined by microscopic examination. In such work, developed structures on the polished surfaces of opaque specimens are chosen in preference to their sections on the ground that the preparation of the latter necessitates the loss of the information sought, in a majority of cases.

The results so obtained indicate the underlying causes for the low strength of concrete produced by the best of materials, largely because of the considerable presence in the mass of occluded air. They also indicate secondary disintegratng actons, asde from such chemical actions as may directly attack the cement, as having a greater importance than is commonly ascribed to them, in concretes exposed to either salt or to fresh water. It is further shown that but a small percentage of the total cement in concrete is hydrated, the greater part lying practically inert in the mass. Lastly, the influence of surface tension of water as a prime factor in making good concrete is demonstrated.

No claim is made that microscopic examination is a cure-all for the ills that affect concrete, but in conjunction with other methods, it is held to be highly advantageous and desirable, especially in the examination of sand and stone and in the determination of causes of failure which would otherwise be impossible of exact explanation.

The slides shown upon the screen were numerous and fully illustrated the speaker's subject. Considerable discussion followed. Mr. McGregor describing his experiments of rattling cement and sand together and then the matrix and the aggregate subsequently together, stated that for 1:3:6 mortars he had some results as high as from 1:2:4 mortars made in the regular way. Mr. Johnson's experiments seemed to corroborate these results. Another speaker described experiments he had made in vibrating concrete. He stated that where concrete had been vibrated on a board 800 times to the minute the briquettes in compression showed a larely increased strength, some of these showing an increase of 98% as compared with briquettes treated in the ordinary way, while an average of 30% to 60% had been shown all along the line. The colloidal matrix had been largely increased. Mr. Lesley referred to the English Jagger process of vibrated concrete in use in London and now established in this country at Attica, Ill. He spoke of the strength of pipe for water and sewage purposes manufactured on this system and stated that evidently the experiments were in the line of doing away with the included air and unmoistened cement described by Mr. Johnson. Mr. Johnson then mentioned experiments that he had made on lowering the tension of the mixing water. The most promising, he said, was the addition of a soda solution. R. J. Wig also spoke on this same subject, mentioning experiments that he had made with alcohol for the purpose of reducing surface tension. Sanford E. Thompson praised the paper as a step in the right direction, but stated that the samples shown in the microscopic slides were taken at random without their history, that the method should be continued in a more scientific way, eliminating all variables; that the paper, however, was a valuable addition to present methods of investigation.

Henry S. Spackman expressed his disbelief in surface tension. He believes that all this shown in the slides was due to coarse particles in the cement. He also said that the cracks shown dated from the earliest mixing of the mortar and were due to shrinkage. P. H. Bates agreed with Mr. Spackman. So far as he was concerned, he believed in wet concrete, well mixed for a long time. The trouble with concrete is that it is not long enough in the mixing. Microscopic slides made of clinker pulverized and unwetted show groupings similar to Mr. Johnson's agglomerations shown in these slides.

P. H. Bates presented a paper on "The Effect of Finer Grinding and a Higher SO_3 Content Upon the Physical Properties of Portland Cement."

The papers by F. W. Swain and A. F. Holmes and by J. A. Kitts were read by title.

An Investigation of the Strength and Elastic Properties of Concrete-Filled Pipe Columns

Messrs. Swain and Holmes reported tests made on concrete-filled pipe columns, filled by the jolting process described in this paper, which showed the columns to have a definite elastic limit and up to this load to be perfectly elastic, the steel pipe preventing permanent set from taking place in the enclosed concrete.

The concrete block made by this process were also found to have an elastic limit, although permanent set was found at the lowest loads.

The column loads at the elastic limit were distributed between the concrete and the steel, and it was found that the former checked almost exactly the stress at the elastic limit obtained by testing the block of plain concrete.

The results of these tests would indicate that a load of 25% of the ultimate could be taken as a safe working load, which conforms closely with the present practice.

Similar tests on larger columns are needed to complete this series and especially tests on columns containing a steel core.

WEIGHT-VOLUMETRIC PROPORTIONING OF CONCRETE AGGREGATES IN TESTING

Mr. Kitts's paper points out that the process of making concrete may eventually advance to such a stage of exactness that the proportioning will be done by weighing the materials rather than by the comparatively crude method of measuring them by volume. Then, as now, we should consider the volumetric proportions, as aggregates vary in character, specific gravity, percentage of voids, etc., so that certain weight (or volumetric) proportions suitable for one rock and sand are not adaptable for another.

The utility of a knowledge of the specific gravity and percentage of voids of a material, in determining volumes of that material by weighing, has not been appreciated. It is the object of this paper to describe the method of weight-volumetric proportioning, to point out its simplicity and importance, and to describe also a new method of progressive proportioning in opposition to the 1:1, 1:2, 1:3, etc., weight proportioning for cement-sand mortar, and 1:2:4, 1:3:6, etc., for concrete.

The metric system of weights and measure will be assumed in the formulas cited.

Committee D-3 on Standard Specifications for Gypsum and Gypsum Products presented a brief preliminary report outlining the work of the committee, undertaken in Dec., 1914.

Committee C-7 presented Standard Specifications for Quicklime and for Hydrated Lime.

Committee C-6 on Standard Tests and Specifications for Drain Tile, outlined further work.

New Books

Farm Sewage—By E. M. Santee, M. D. Published by Orange Judd Co., N. Y. C., cloth, 7″ x 5″, 32 pp., illust., 50c.

To people so located as not to have sewage disposal systems available, the septic tank has come to mean the one reliable means for solving the problem of safe sanitary conditions. This little book is written by one who has spent some years in the investigation of sewage disposal under the auspices of the state of N. Y., and he has condensed the whole story into this volume. The subject is made so simple that this book may be considered a septic tank primer. A brief discussion of sewage and the bacterial agencies on which the septic action is based is followed by a description of the size and construction of the tank in detail, reducing the construction to the simplest possible form.

The book details the cost of a septic tank as actually constructed under farm conditions and gives valuable hints on the installation of a sanitary plumbing system.

By no means the least valuable part of the book is a catechism, answering questions which many inquirers have asked covering special points on the construction and operation of septic systems.

The author is to be congratulated on the exceptionally elementary and yet comprehensive way in which he has treated this important subject.

Home Builder's Guide—By William Arthur, David Williams Co., N. Y. C., cloth, 7¾″ x 5″, 186 pp., illust., $1.00.

This is not a book on concrete. It does contain much information on the building of homes which is of value not only to the layman, but to the architect and the builder. It is written in Mr. Arthur's characteristic, readable style and shows the unmistakable stamp of the practical man. We regret that in the brief space devoted to the use of concrete and concrete units in house building, Mr. Arthur has not drawn his material from the best modern practice. He has undoubtedly written this section from the standpoint of the material which can be obtained in the ordinary concrete products plant, but has not attempted to show the possibilities of concrete which are now generally available. In spite of this criticism, the book is well worth reading.

Manual Training Course in Concrete—Assn. of Amer. Portland Cement Mfrs., Philadelphia, Pa. Paper, 9″ x 6″, 100 pp., illust.

This is a timely book and one that should have a large field of usefulness. Concrete is so extensively used as to make the need of a short course in manual training schools imperative, though the scope of such work is necessarily limited by the time available for its presentation. This book outlines a course in carefully graded sequence.

The subject is introduced by a brief history of the manufacture and use of Portland cement, followed by a description of aggregates and their requirements. Proportioning, mixing and placing are taken up briefly but comprehensively, followed by short discussion on form work. Other subjects treated in the text are walls, blocks and other units, surface finish, fence posts, walks, curbs, etc. The laboratory course includes mixing and proportioning, and making small test beams, together with details of a testing machine which can readily be made by the students of a manual training course. Following is a series of exercises on form building and the manufacture of various plain and ornamental objects in concrete.

By no means the least valuable feature is the brief bibliography appended to each section of the work, furnishing a guide to supplementary study and experiment by the student. Concrete men should use their influence to secure for students in their localities the benefit of training along the lines suggested by this work.

Exporters' Enclyclopaedia, 1915—Exporters' Encyclopaedia Co., N. Y. C. Cloth, 8″ x 5½″, 1,152 pp., $7.50.

Every manufacturer who is shipping goods to foreign markets will be interested in the 1915 edition of the Exporters' Encyclopaedia. This volume gives data on steamship lines, agents, commerce and industries of various countries, customs house information, and many other items necessary to the foreign shipper. It has been brought up to date as far as possible under the unfortunate conditions caused by the European war, and bulletins are issued in connection with it, giving the latest advices possible to obtain concerning conditions of transportation in the countries affected. It furnishes details as to Consular regulations and their cost, indicates when freight must be prepaid and the necessary information for making bills of lading, and, in fact, it is intended to anticipate every need of the exporter.

Concrete Street Signs and Standards—Letters in Colored Concrete

Concrete street signs and various designs of standards make an interesting specialty in concrete products manufacture with W. H. Filer, Grove City, Pa. A special feature of this work is in the letters and ornamentations in black and in colors cast at the same time as the body of the unit of which they form a part. Mr. Filer has been experimenting with the colored mixtures for years to get not only permanent colors but a cement mixture containing them which might be expected to last as long as the object of which they are made. His process, including his method of casting the colored design dovetailed in the body of the work, is of course not made public. Last year his street sign was introduced in Pittsburgh, the signs on granite concrete standards being made for the Bur. of Engrg. under the following specifications:

Reinforced concrete street signs and posts shall be furnished complete as shown on attached plans. The contractor shall furnish all material, including the reinforcement and rods, as shown on the attached plans marked "Concrete Criss-Cross Sign and Post."

The sign plates shall be made separate from post and so constructed that they can be placed and maintained parallel with the intersecting streets and shall show the street names as supplied by the Bur. of Engrg., Div. of Surveys. All letters to be of exact design as shown on the plan designated.

The letters shall be of monolithic construction molded in a plastic state, dovetailed with the remainder of the material. The letters shall be of a solid black mineral color that shall not fade or discolor with age. The posts and signs shall be finished perfectly smooth, with sharp straight edges and in every respect equal to sample in the office of the Bur. of Engrg., Div. of Surveys.

Designs for some of these standards and signs are shown in the accompanying details and in illustrations from photographs.

Manufactured stone "has a right" to look like stone—only, it should look better because the kind of ingredients and their manipulation are under constant control. Architects who use concrete stone of the best quality find that it weathers better than natural stone.

"Hap." Hazzard says: "The sand *looks* clean—I *guess* it's all right."

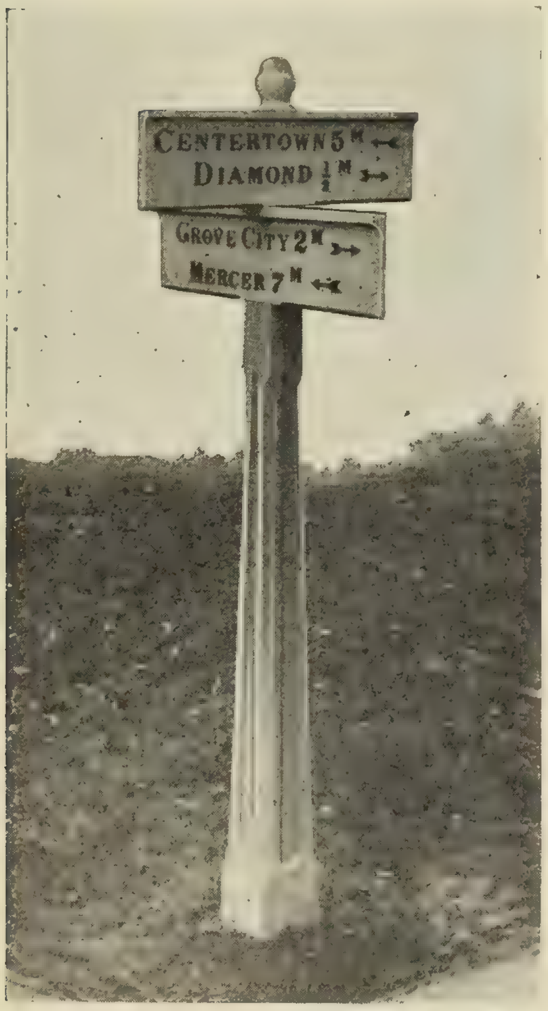


Fig. 1—Criss-Cross Sign and Standard on Country Highway

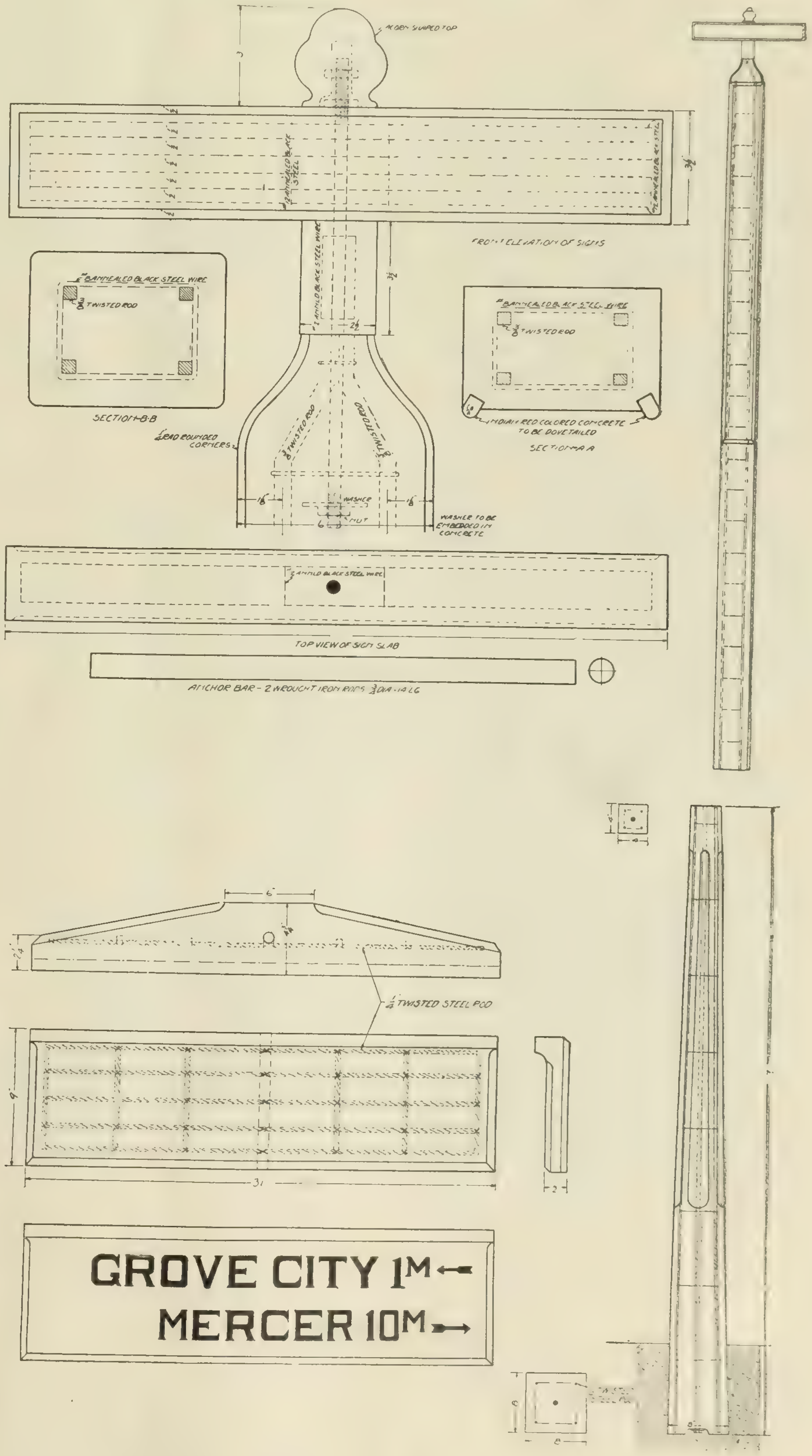


Fig. 2—Details of Reinforced Concrete Standards and Signs

New Equipment, Methods and Materials:
New Tools with Which the Industry Works □ □

This magazine will not publish "reading notices," so-called, for the benefit of advertisers. These pages are edited for the Reader, as are all other pages in "Concrete." Manufacturers are constantly producing new and better methods and developing old methods, materials and machines. The progress of the concrete field is measured by the development of its tools. All developments along these lines are of real interest and importance to men who want to improve the quality of their work, decrease its cost, increase its quantity. This department is for just that kind of Editorial material. We, therefore, welcome detailed announcements which will be of practical value to Readers. Under no circumstances will this magazine publish any announcement simply because an advertiser asks it, nor refuse publication because a non-advertiser asks it. Material must carry information of real consequence to the reader. All material will be edited on that basis regardless of the source from which it comes.—**The Editors.**

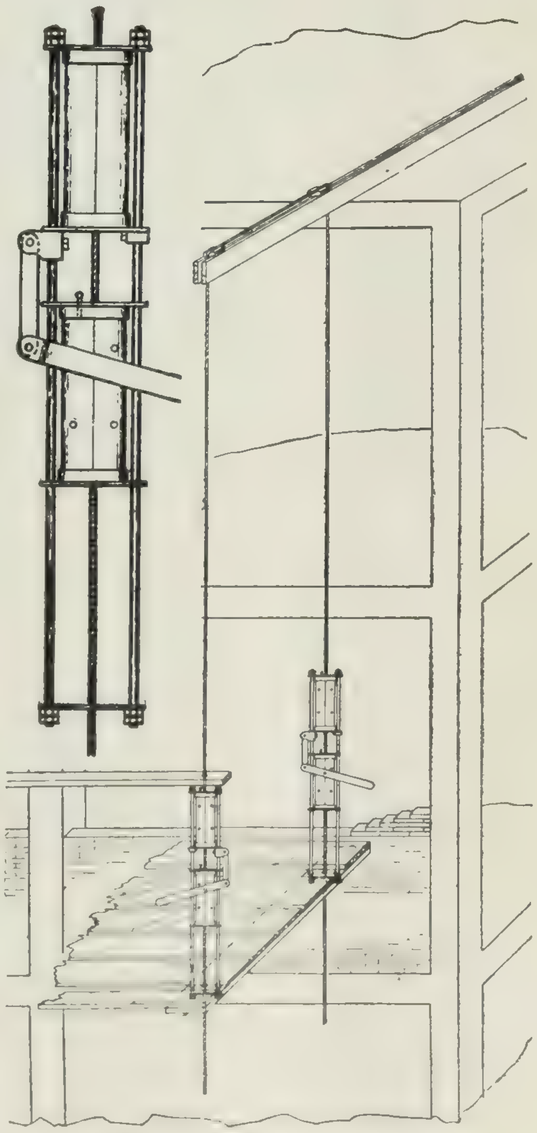
A New Scaffold Hoist Machine

There has been placed on the market the scaffold hoist machine shown in the accompanying illustrations. It is known as the Little Wonder scaffolding machine[1] and is 4′ high, 7½″ wide and 2¼″ thick. A test load of 7,270 lbs., applied to a pair of machines, left no indication on the cables that the load had been carried by the clutch.

The manner of installing the scaffolding machine and an enlarged view of the machine are illustrated. The outriggers may consist of two 2-in. x 8-in. x 16-ft. planks with a 1¾-in. block between them and a 1-in. x 6-in. block nailed over each block for solid bearing for the cable.

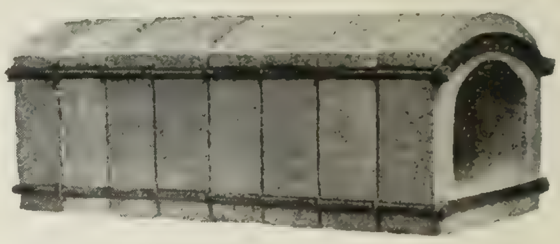
The outriggers are spaced about 10′ apart and set so that the inner cable is 6″ from the building line. The putlog or cross-beam is made any length to correspond to the width of the platform required. Three ¾-in. holes are bored 10″ from the wall end of the putlog, two holes for the rods of the machine and one for the cable. At the other end of the putlog these holes are located 4″ from the end.

The advantages claimed are that the cables are not subject to severe wear as when wound on a drum and that the scaffold can be used for the entire height of tall buildings without changing outriggers.



Little Wonder Scaffold Hoist

Culverts Built of Pre-cast Sections



Culvert of Pre-cast Sections

The accompanying illustration shows the chief characteristics of the Gibson[1] sectional reinforced concrete culvert. The sections, made of a wet mixture of concrete, are cast in wood molds of simple design. They are reinforced and a series of sections is held in position by recessed longitudinal bars, top and bottom, at either side, these passing through iron bands, extending between sections from one side to the other. The points in favor of this culvert are that it is a shop-made unit, properly manufactured and cured and hauled to the site of the highway or railway improvement for installation, which is accomplished quickly without a long interference with traffic, as is necessary where monolithic culverts are built in place. The culvert sections can of course be made in all the common sizes and by changing the top sections in the mold can be cast to be used in pairs, each part describing in its top surface half the crown of the culvert. These culverts have been in use in Mont., Wyo., Minn. and the Dakotas for several years.

A New Adjustable Shore

Along with the constant improvement in almost every phase of concrete construction one detail has re-

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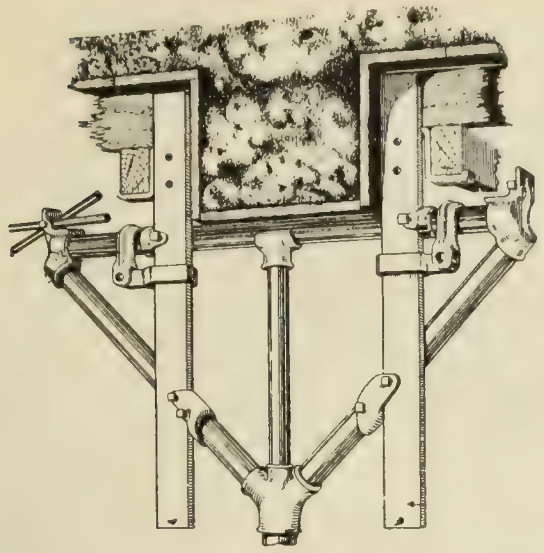
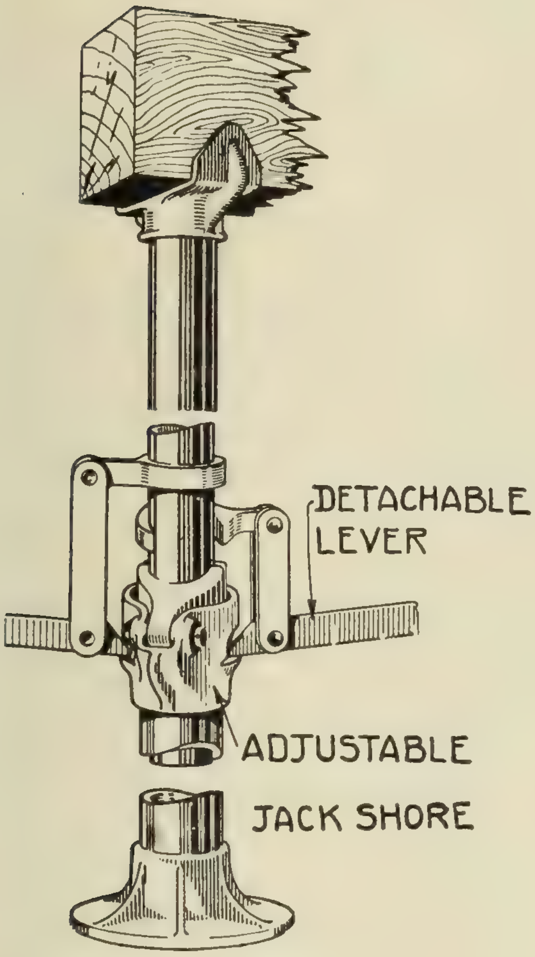
[2] The Eclipse Scaffolding Co., Omaha, Neb.

[1] John Gibson, Fromberg, Mont.





Adjustable Form Shore

mained substantially unchanged since the erection of the first concrete buildings. Timber shores cut to length and wedged have seemed so simple that in spite of the enormous waste of lumber and the time involved in placing wedges few have given thought to a better way.

The illustration shows a telescoping shore.[1] This shore is made of two pieces of iron pipe fitted at the bottom with a strong base and having a cap at the top. Secured to the upper end of the large pipe is a malleable iron casting with two automatic locking dogs which grip the opposite sides of the pipe and hold it in any position. These dogs are hinged on large steel rivets and can be instantly released. The casting and gripping dogs are 4′ 6″ from the floor. The inner tube can be instantly raised to the proper height and the locking dogs hold it in this position.

For raising any load or adjusting the height a strong lever is used. This lever has a yoke casting which encircles the small pipe and is connected to the lever itself by two steel links. The short end of the lever rests on the large casting as a fulcrum. By operating this lever the finest adjustment can be effected, the dogs automatically gripping the smaller tube the instant the lever is released. This detachable lever can be instantly removed and taken to the next post.

In case of an extra heavy load two levers may be used on opposite sides of the post, as shown. For ordinary adjustment one lever only is required. Each one of these shores has an adjustment of 3′ 6″, the closed height being 9′ and the extended height 12′ 6″. The shore may be lowered by the use of the detachable lever to raise the load slightly, allowing easy release of the engaging dogs.

The shores are fitted with a variety of heads—plain round cap, timber head as illustrated and various types for supporting beams, one of the more elaborate forms being illustrated.

The "C-S" Column Form and Shore

Every builder deprecates the great amount of lumber necessarily used and rendered second-hand in building and shoring forms. One of the latest systems intended to eliminate this loss is shown in the accompanying illustrations. Fig. 1 is a cross-section of an adjustable column form which is claimed by the manufacturer[1] to allow extreme adjustment and effect a great economy in column form work.

Two sizes of column forms afford an adjustment from 16″ to 30″ and are adjustable vertically from 9′ to 16′. The total weight is about 500 lbs. and the form collapses for convenience in transportation. As evidenced by the drawing eight-sided columns are provided for.

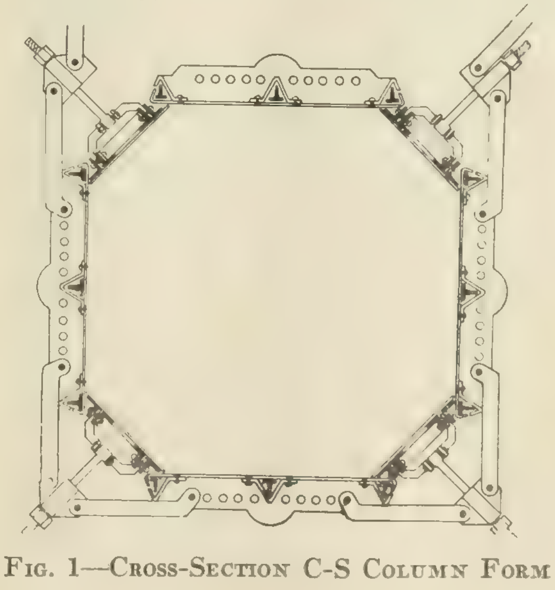


Fig. 1—Cross-Section C-S Column Form

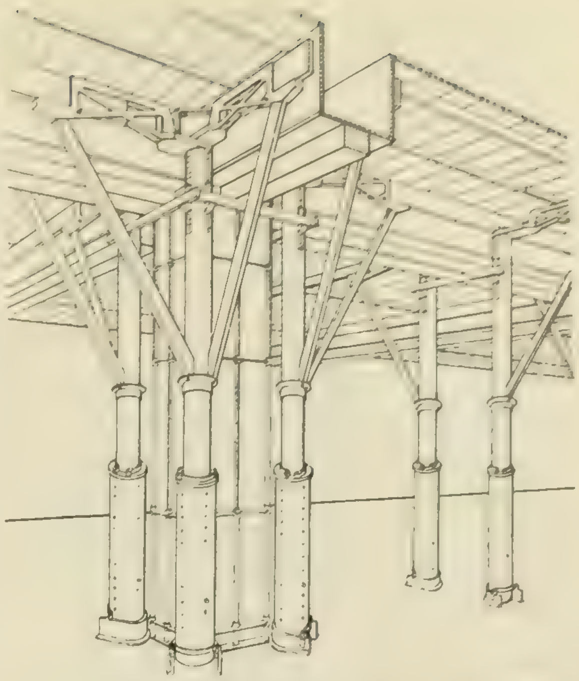
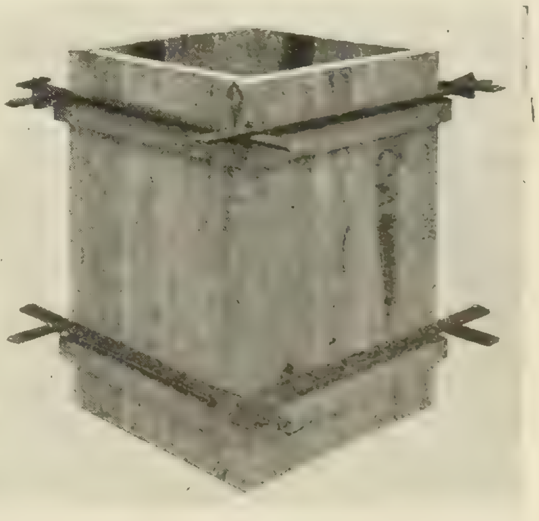


Fig. 2—The C-S Column Form Erected

Fig. 2 shows the column erected and also an adjustable shore arranged to support beam forms. It is claimed that this equipment will effect economies in time and lumber, making it a paying investment for the builder.

The Penn Metal Co., Boston, has taken over the business of the Eastern Expanded Metal Co., and will hereafter act as the New England sales agent for Steelcrete expanded metal. George Taylor, who has been for some years with the Eastern Expanded Metal Co. will continue with the Penn Metal Co. and will handle Steelcrete products in New England territory as heretofore.



The Mims Column Clamp

A Column Clamp

The illustration shows a new clamp[1] which can be adapted readily to octagonal as well as to square columns. The construction is very simple, two corners being bolted and adjustable, the other corners secured by oval slotted clips which are forced into notches as shown by means of a special lever.

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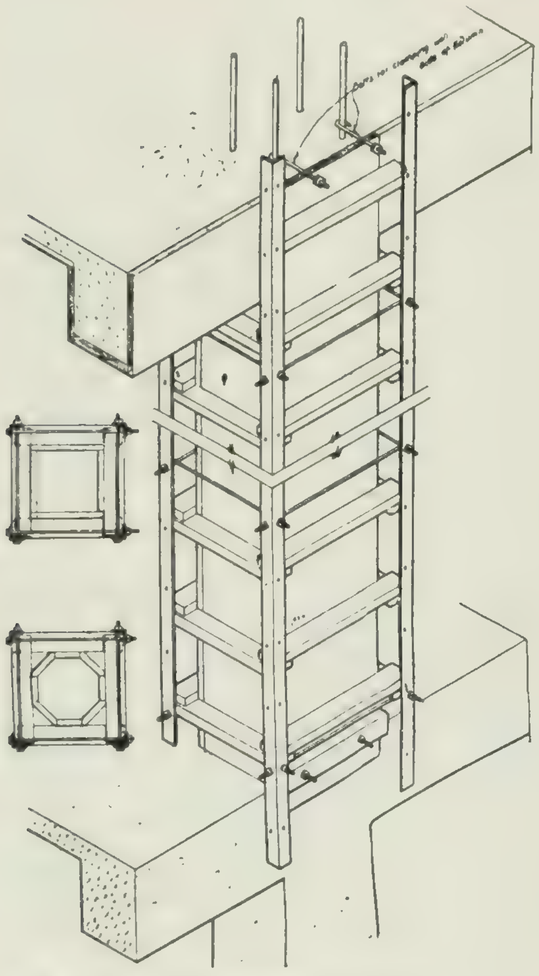
[1] Gemco Mfg. Co., Milwaukee, Wis.

[1] C-S Concrete Form Co., 716 Dwight Bldg., Kansas City, Mo.

[1] J. R. Mims, Luray, Va.

The New England Column Clamp

This type of clamp[1] has been in use for some time and has proved very efficient. It is extremely simple and can be adapted to columns of various shapes. In the illustration it is shown in use on a wall column where, by the use of longer angles, it forms a support for beam forms. It is claimed for this clamp that it is low in first cost, that it effects a saving in assembling and striking, that forms are easily squared and that depreciation is very small.



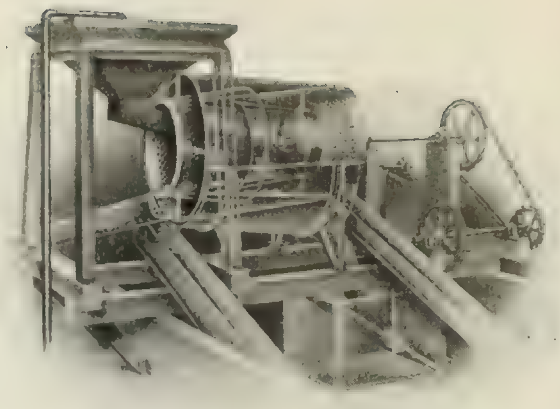
New England Column Clamp

These clamps can be purchased or the right to make them can be secured from the manufacturers.

A Combined Gravel Screen and Washer

Users of sand and gravel are fast realizing that washing is a necessity. Excellently equipped plants are being built to provide washed, screened and standardized products.

The screen illustrated[2] was developed for private use by a gravel dealer. It is designed to reduce the cost of plant construction by making less framing necessary and reducing the length of platforms, shafts, etc. Three frustrum shaped screens are combined with each other. The material and water are introduced into the central screen, which retains the coarse material and passes the fine grades to the others. It will be noted, the finest screen being outside, that its surface is greater and its motion faster, so that the screens act together uniformly. The final washings are conveyed to an ordinary settling tank, and the other materials to suitable bins.



The Biesanz Sand and Gravel Screen

Beanfield Gravity System for Distributing Concrete

An apparatus for conveying concrete by gravity has been invented by Rufus McC. Beanfield, San Francisco, Cal. It consists of a distributing system of troughs, pipes or other conveyors used in connection with an elevator tower.

HOISTING ARRANGEMENT

The tower may be of any suitable construction, rising from a base on which may be placed a mixer. In the tower is an elevator, operated by a cable, driven by a hoisting mechanism.

Secured to the tower near its upper end is a receiving box into which the elevator delivers the concrete in the customary manner, as shown in Fig. 1. This box has two discharge spouts, one near the bottom of each side, and each spout is fitted with a controlling gate, which is operated by a handle, as shown in Fig. 3. Secured to the box on each side around the spouts is a short chute, each chute having two divergent branches. Under the outer end of each divergent branch is a short head-trough, supported from the tower by links.

Within the box, as shown in Fig. 1, is removably fitted a directing plate. In the position shown this plate delivers the concrete to the spout on the right; but when the plate is changed to the opposite angle, it delivers the concrete to the spout on the left. Its position is such that it can close either branch and open the other.

The main trough is composed of several freely overlapping sections in end alignment, being suspended from and carried by any one of the guy-cables by suitable hangers. The upper end of the main trough lies under any one of the head-troughs in position to receive the concrete.

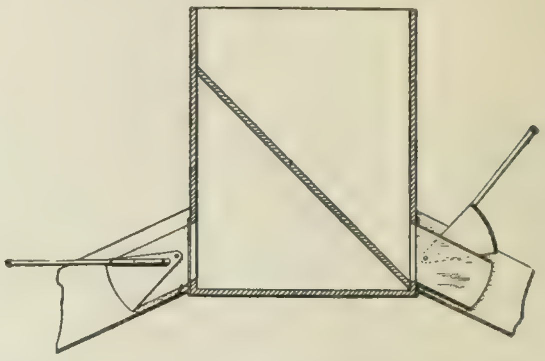


Fig. 1—Vertical Section of Fixed Receiving Box on the Tower

Sketch shows the means of directing the concrete, and connections, with their controlling gates

Suspended from the guy cable from which the main trough is suspended is a hanger rod, hung from the cable by its hook. Upon this hanger is carried a hopper, revoluble on the hanger as an axis by means of a base bracket, as shown in Fig. 2. Upon the hanger is mounted and adapted to be vertically adjusted by means of a collar having a set-screw, a spider, the arms of which are hooked into the terminals of the main hopper. The other ends of the spider-arms are secured to a shield, the lower end of which fits freely into the hopper, and its upper end is carried by an adjustable collar on the hanger-rod.

The hopper is fitted with a discharge spout. Under this spout lies the upper end of the second trough. This trough is similar in construction to the main trough, that is, composed of articulated sections. It is suspended by bails from a cable, the upper end of which is secured to a guy-cable, and the lower end of which is connected to a fixed point by a block and tackle. This second trough may be the terminal of the distributing apparatus or more troughs may be added. For example, provision for a third trough is shown in Fig. 3.

OPERATION OF BEANFIELD GRAVITY SYSTEM

The apparatus is operated by carrying the concrete up by the elevator and dumping it into the box where it is directed by means of the plate into one of the spouts. By the plate in

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[1] New England Column Clamp Co., Boston, Mass.

[2] Biesanz Stone Co., Winona, Minn.

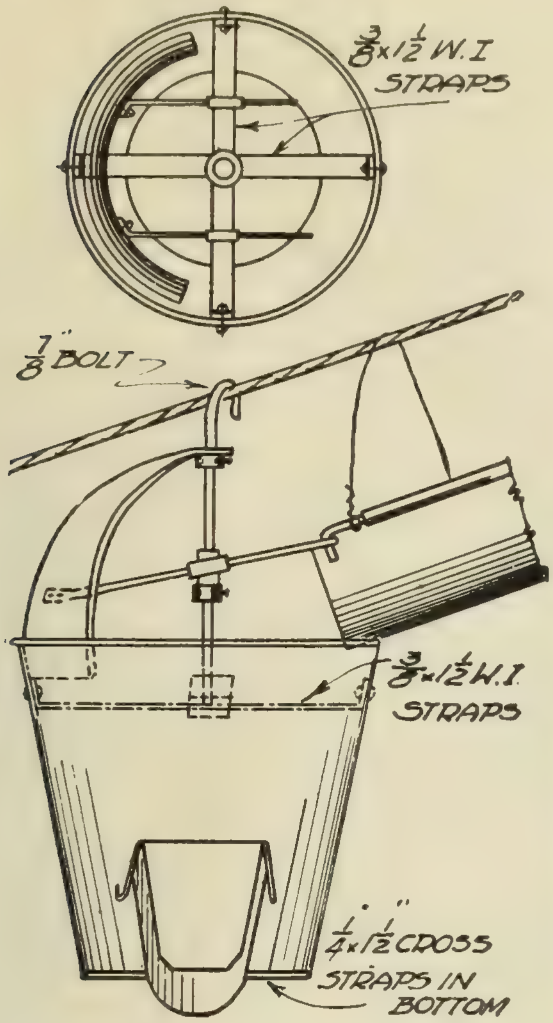

Fig. 2—Elevation of the Revoluble Head Hopper or Distributing Bucket of the Second Trough

the chute of this spout, it is directed into that head-trough with which the main trough is in communication. The concrete passes down through the main trough and is delivered into the hopper which delivers it to the second trough.

Assuming the second trough to be the terminal of the system, it will be seen that by releasing the lower end of the cable from which it hangs and carrying the cable around and securing it in successively fresh positions in its circle of movement, the second trough turns with its revoluble hopper through a complete circle and will deliver the concrete throughout its range of movement. The area thus served can be enlarged by removing some of the terminal sections of the main trough, adding to the sections of the second trough, slipping the connections of the cable and the hopper hanger rod farther up on the guy-cable, and lengthening the cable by its block and tackle.

When the area within range of the apparatus has been served, the main trough is unslung from the guy-cable which previously supported it, and the trough is moved bodily to a new relation with another head trough of the box and is then suspended from another of the guy-cables. In this readjustment to a new position, the second trough accompanies it, the cable of this trough having been freed.

When the parts are in their new position, the various controls of the box are properly rearranged for delivering the concrete to the main

trough, and the operation proceeds until the distribution to the new area has been completed, whereupon a third rearrangement is had, and so on through the entire circle. In a further range of action, the third trough may be used, this trough having an operation relative to the second trough similar to that which the latter has to the main trough, and, moreover, the third trough may be relatively short and light, adapting it for easy manipulation through its handle.

The essential feature of the Beanfield invention lies in the suspension of the distributing system from a catenary support.

A Conveying Concrete Mixer

The concrete mixer is so highly developed that a really radical change in basic principle is seldom found, yet the accompanying illustrations indicate that the possibilities of the mixer field have not been exhausted. The construction of this mixer is clearly shown in Figs. 1 and 2. A toothed sheave through which the fall from the derrick is rove is geared through an idler to the drum. The action of hoisting or lowering by the

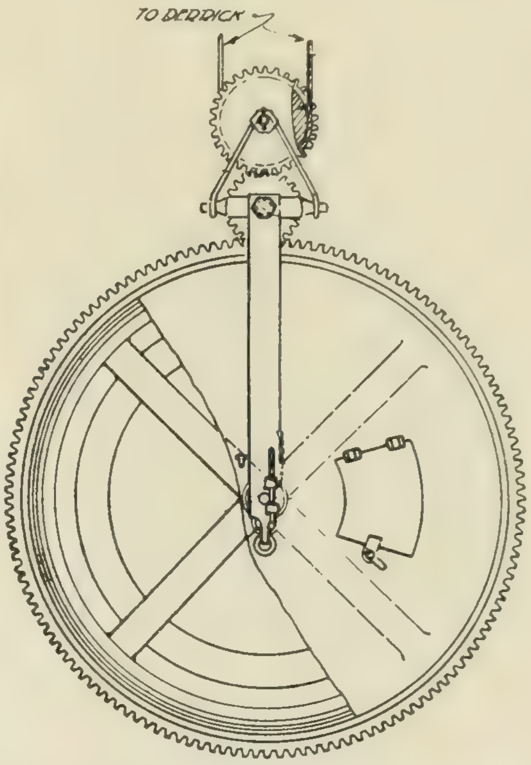

Fig. 1—End View of Derrick Concrete Mixer

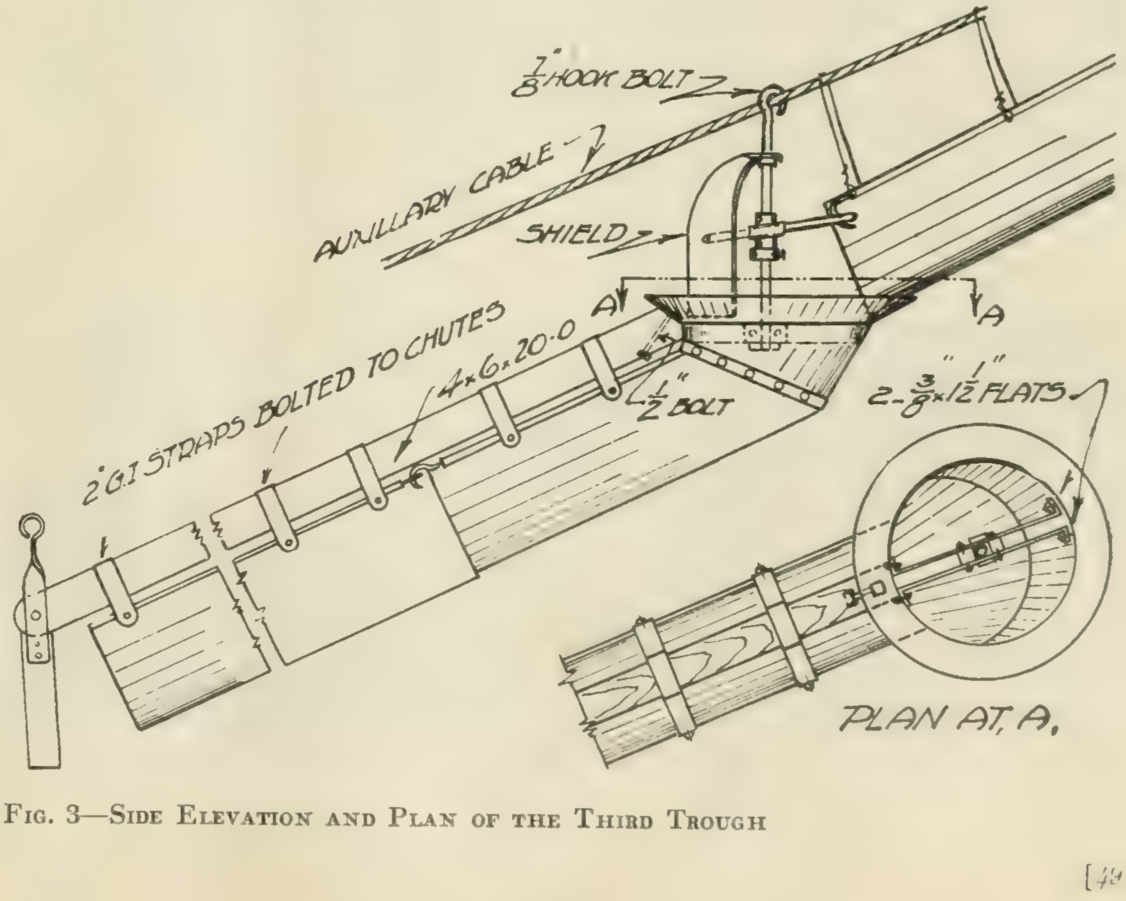

Fig. 3—Side Elevation and Plan of the Third Trough

derrick revolves the mixer through this gearing. Two or more mixer drums are usually provided, to keep derrick and men in continuous action. The sheave is so arranged as to be changed readily from one drum to another or to be used for hoisting other materials.

Some of the advantages claimed for this equipment are: Elimination of extra mixer power plant; ability to take materials from any spot reached by the derrick and to deposit concrete at any other spot without intervening labor; an exceptionally thorough mix and the assurance that the concrete is deposited in a perfectly mixed condition, as it is agitated to the last second before being placed; the ability to deposit concrete in narrow forms without delay or waste as indicated at Fig. 2 and Fig. 3, extreme right.

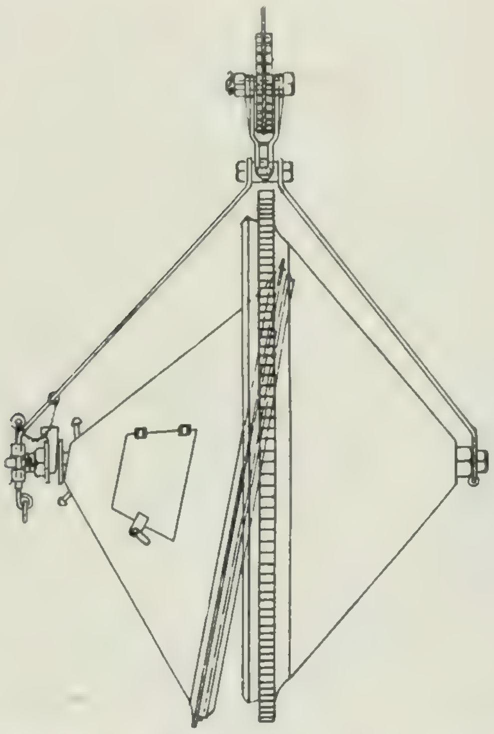

FIG. 2—SIDE VIEW OF DERRICK CONCRETE MIXER

This mixer has been used successfully for placing concrete under water, using a canvas chute. The concrete being constantly mixed and kept from contact with the water till the instant of its release, practically no cement is washed away.

Fig. 3 shows several views of the mixer as used on the Metropolitan Pumping Station, Boston, and it is interesting to note that the concrete roof of this building was watertight before roofing was applied, and this without special effort to make it so, indicating the great uniformity of the concrete as placed. Cost figures were kept on this and other jobs, showing an average labor cost of $1.25 per cu. yd. for concrete in slabs and small sections.

C. C. Turner[1] designed and constructed this mixer for use on his own work, and owns patents covering the device and also a modification designed to run on a cable or track.

Trade Publications ☐

The Calculagraph for Timing Labor—Calculagraph Co., N. Y. C., paper, 6¼" x 3¾", 16 pp., illust. This little booklet considers in detail the Calculagraph for cost accounting in factories and for general use. Several types of Calculagraph card racks are also shown, accompanied by a price list.

The Scientist, January, 1915—The Goheen Mfg. Co., Canton, Ohio, paper, 9" x 4", 12 pp. This is the first issue of a monthly house organ to be devoted to various preservatives, damp-proofing or waterproofing problems that arise, together with illustrations of important work under construction, giving detailed information as to conditions met and how they were overcome. "The Scientist" is claimed to be a departure from other publications. A special section will be devoted to answering or solving any queries from its readers. It is edited by C. J. Robison, C. E.

Portfolios Showing Structures Made from Pit-Run Gravel Furnished by the J. Fred Smith Gravel Co., Dallas, Tex., paper, 11" x 8", 24 pp., illust. This booklet shows in detail the operation of the sand and gravel plant owned by the J. Fred Smith Gravel Co. Photographic views are given showing structures wherein material furnished by this company was used.

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[1] Const. Supt., 18 Beach St., Salem, Mass.

Current Prices — Concrete Materials ☐

Portland Cement—The cement market continues rather dull, with practically no change in prices quoted last month. In certain quarters the demand is increasing slightly. Prices given are f. o. b. cars at points named, including cloth sacks, for which, in general, 40 cts. per bbl. (4 sacks is refunded on return in good condition. Prices per bbl. (including 4 cloth sacks) are as follows: Boston, $1.46; New York, $1.22; Chicago, $1.46 to $1.55; Pittsburgh, $1.46; New Orleans, $1.58 on dock; Memphis, $1.75; Cleveland, $1.54; Detroit, $1.55; Indianapolis, $1.58; Columbus, $1.58; Cincinnati, $1.59; Toledo, $1.59; St. Louis, $1.45; Milwaukee, $1.58 to $1.63; Minneapolis and St. Paul, $1.67; Duluth, $1.82; Kansas City, $1.48; Omaha, $1.48; Spokane, $1.75; Seattle, $2.40; Portland, Ore., $2.40; Tacoma, $2.40.

Crushed Stone—1½-in. stone, prices per cu. yd., f.o.b. cars in carload lots, unless otherwise specified. Boston, 80 cts. per ton at the quarry; New York, 95 cts. in full cargo lots at the docks; Chicago, $1.15; Spokane, $1.00; Portland, Ore., $1.15; Seattle, $1.50.

Gravel—Prices given are per cu. yd. f.o.b. cars in carload lots unless otherwise noted. New York, 80 cts. in full cargo lots at docks; Chicago, $1.15; Spokane, $1.00; Portland, Ore., 85 cts.; Seattle, 75 cts.; Tacoma, 75 cts.

Sand—Prices are per cu. yd. f.o.b cars in carload lots unless otherwise indicated. New York, 50 cts., full cargo lots at docks; Chicago, $1.15; Spokane, 75 cts.; Seattle, 75 cts.; Portland, Ore., 85 cts.; Tacoma, 75 cts.

Reinforcing Bars—The bar market is normally active in New York, Chicago and St. Louis, with sales fair; in San Francisco deformed bars are more in demand but by no means active. July deliveries will be made on a basis of $1.25 per cwt., Pittsburgh, with prevailing extras for bars under ¾" or base. The following are quotations on base bars per 100 lbs., for mill shipments from other points, f. o. b. cars: New York, $1.419; Philadelphia, $1.409; Chicago, $1.439; Spokane, $2.05; Portland, Ore.,

(Continued on Adv'g p. 77)

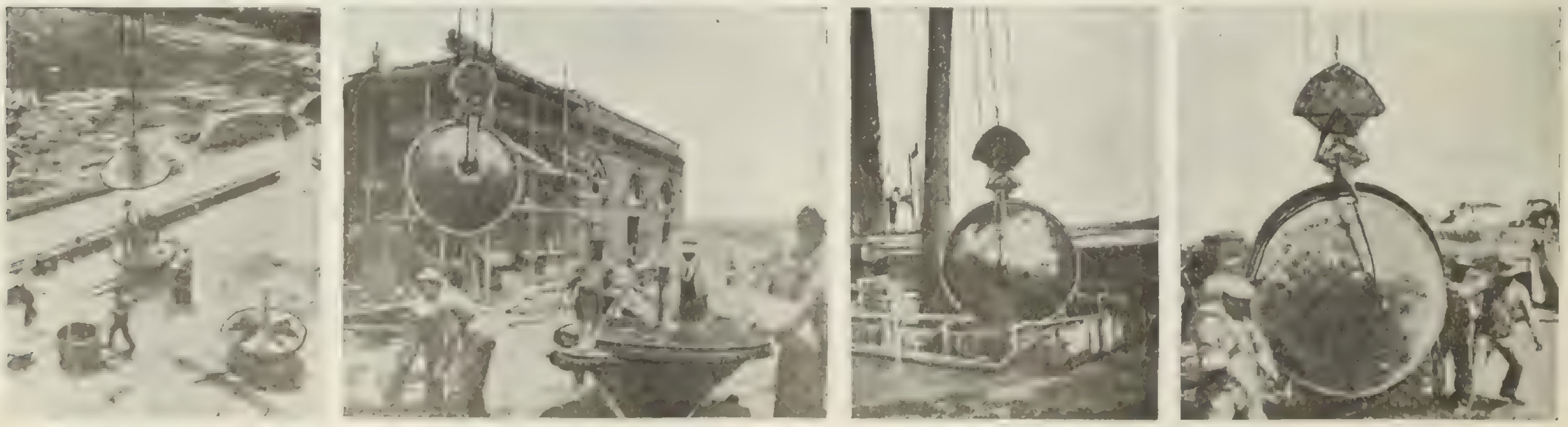

FIG. 3—DERRICK MIXER ON METROPOLITAN PUMPING STATION, BOSTON

Concrete

Cement Age

Vol. 7 Detroit, August, 1915 No. 2

"Concrete Buildings Burned to Ashes"

THE head line, "Concrete Buildings Burned to Ashes," in a Portland, Ore., paper indicated a conflagration of startling proportions, until further reading disclosed the fact that the buildings which burned were of frame construction in the *town* of Concrete, Wn. The town was evidently better named than built.

Better Aggregate

INQUIRIES reaching this magazine indicate an awakening by those in the concrete industry to the importance of properly selected aggregates. The day when unsatisfactory concrete could be laid to the cement manufacturer has all but passed and the importance of tests of sand and gravel has become recognized.

Aside from the danger of aggregate that is plain "dirty," there is much to be gained by an intelligent study of material with a view to proper combination to secure maximum density.

Mr. Dieckman's article in this issue is a guide post to better concrete.

Concrete in Sea Water

COMMENTING upon Nathan C. Johnson's investigations with the microscope in the study of concrete, *Concrete and Constructional Engineering*, London, lays special stress upon the effect of the investigations in maritime construction. It quotes Mr. Johnson's remark: "In sea water construction especially it is probable that the defects which induce failure lie primarily not so much in the cement, providing cement of proper quality be used, as in the improper proportioning of aggregates, or in poor mixing, or in a combination of the two," and draws thereto special attention in its application to concrete for salt water work. All this goes largely to corroborate early investigation of the same subject and goes further to emphasize the importance of good workmanship in concrete for salt water. Way back at the Engineering Congress at St. Louis in 1904, a paper by two Japanese engineers on the building of the port of Kobe in Japan brought out in the clearest way the importance of the proper proportioning of aggregates and the still greater importance of the proper compacting of the mass of concrete that is to be subjected to the action of salt water.

A Second Conference on Concrete Road Building

A YEAR ago last February there was a National Conference on Concrete Road Building—because that conference was needed. Last February there wasn't any such conference because it wasn't needed. Time hadn't elapsed in which to follow out the practice indicated by the first conference and to apply the test of experience. Now, however, concrete road building has become so general and there is so much new thought on the subject that the Second National Conference on Concrete Road Building, announced for Feb. 15-18, 1916, should be a meeting worth while. It is not necessary to repeat here that the first conference was splendidly productive. But that is why, with similar management, much can be expected from the second conference.

Concrete Architecture

A CERTAIN New York architect who is an enthusiast in the field of concrete and one of this magazine's very good friends wrote a letter a while ago in which he told CONCRETE where it had done wrong. He made particular reference to certain illustrations in the January, 1915, House Building Number and for very good reasons these particular references should not be quoted. What he said of concrete house development, however, and of some of this magazine's illustrations in general, is very severe, but too good to keep. Here it is:

> How can you expect to interest big, broad, intelligent minds with a huge capital that they can command in the development of concrete in competition with stone and brick—when you allow your pages to be marred, as they sometimes are by illustrations that serve no better purpose than to drive home the truth that no building material is more hideous than certain forms of concrete? You ruin a chance of attracting the attention and winning the support of men of culture and wealth in order to cater to some two-for-a-cent builder or maker of a particularly vulgar form of concrete product. If you wanted a good looking reliable fur coat, would you give

the order to a trapper? He certainly knows a good deal about fur. If you wanted a good fitting, serviceable pair of shoes would you have them made by a trunk manufacturer? He, undoubtedly, knows a lot about leather. If you wanted to entertain a distinguished company at dinner, would you engage your butcher or grocer to cook it? They can probably add something to your knowledge of meats and vegetables, wines and cigars. Yet the answer to the foregoing questions is unhesitatingly "no." A man who knows little or nothing of the principles and practice of architecture should not be permitted to disfigure the landscape with a house designed and built "by himself," or by some equally untrained individual, nor should you lend your approval by advertising his ignorance and incompetence, thus discouraging those of your intelligent and discriminating readers who are trying to raise concrete to a high plane of esthetic excellence and attract to it the attention that its admirable qualities deserve.

Why should a layman consider himself a competent critic of domestic architecture when he would never question the opinion of his lawyer or his doctor, or advance any views upon finance or attempt to explain a problem in engineering? One answer is that in the wide field of art, domestic architecture seems to have been a common heritage of the public, due perhaps to the environment of the four walls. floor and ceiling, with the accompanying furniture, draperies and bric-a-brac that have encompassed the human being since the cradle. That these surroundings and chattels are not highly "artistic" is not always discreditable to their possessor. If, for example, he has lived his life in the narrow, high studded rooms of a city block dwelling amid gloomy walnut trimmings and Victorian furniture, is there any wonder that his sense of beauty and proportion in things architectural has been dulled and warped? No—but he should frankly acknowledge his deficiency and call in a trained adviser when there is serious work to be done, as he would in a case of sickness or of law. If a thing is worth doing at all, it is worth doing well—and it is cheaper in the end to do it right in the beginning.

It is a common occurrence for a woman possessing no qualifications derived from study and mastery of the principles of decorative art—to march boldly into a wall-paper shop and after hours and often days of internal struggle finally select the papers which in *her* opinion are suitable in color and design for the covering of the walls of the rooms in her home. Yet she would probably be shocked and feel insulted if her taste were questioned. One of the most embarrassing moments in the architect's intercourse with his client is when there arises a question of taste. Some take it as a personal affront—as if accused of wearing soiled linen. Taste is a product of personality and environment, and good taste is merely a measure of local standards. The Indian's wigwam may conform more closely to the precepts of good taste than the American millionaire's chateau. It takes years of study and an intimate association with recognized works of art to acquire good taste, unless you are born with a predilection for it.

It is true that for many years there has been a prejudice against the architect—largely deserved. He has been regarded either as a luxury, a necessary evil, or, as was the case with a great majority of building operations in America in the latter part of the nineteenth century, his services were never even considered. Witness the solid phalanx of brownstone that until the last few years has ruled with unbroken sway the resident streets of New York. Behold still the dreary facade of brick and well-scrubbed marble "stoops" of Quakerdom, and the fat bellied progeny of Tweedledum and Tweedledee that line the thoroughfares of staid old Boston. All the product of the speculative builder. All begat of the same ill-conceived plan with only such occasional and trifling variations as his barren fancy might dictate.

The architect is just beginning to show the public that he is a valuable member of society and that his labor may be employed with advantage. By slow degrees he is convincing the people that beauty and refinement of line and form and a good sense of color and proportion in the buildings he designs mean not only something pleasing to behold but a profitable investment. That a well-planned building of tasteful design is a valuable asset is now an accepted fact with experienced proprietors. Not long ago it was a common saying that the value sunk in the home could never be dug out again and that any subsequent profit must come from a rise in value of the land. That this is no longer an axiom the writer has plenty of evidence at hand.

What the New York architect says is sound sense. This magazine felt called upon to tell him, however, that he had missed the point of some of the matter published in relation to concrete houses.

Some matter is published for the architectural suggestions which it carries; other matter is published for its structural suggestions; and still other matter is in the way of a mere report of work done, largely in the nature of a mechanical experiment, and has to do with the equipment used and the methods employed.

It is a matter of very keen regret that in order to give readers of this magazine the benefit of purely structural and mechanical ideas, the use of photographs which are hideous to the architect, is unavoidable.

The real problems of the future concrete architecture are not solved when a rich client gives an architect a broad and sweeping commission to build him a reinforced concrete house—where the cost is a matter of minor consideration. Two trips over ones ten fingers will come near to enumerating the architects in this country who have made valuable contributions to concrete architecture in a broad sense. The architect who designs a magnificent house to be erected with concrete units is doing commendable work which this magazine likes to recognize. When he designs a fine reinforced concrete house for a client with means, and is unhampered by a necessity for rigorous economy, this magazine will be at some pains to describe the interesting features. Yet the thing this magazine desires most keenly, is to encourage the development of concrete house architecture along such lines as will put good homes—weatherproof and fireproof, attractive and individual—within reach of the very numerous citizens who can't go to an architect and give him free rein in the matter of expenditures. It is in the solution of this problem that architects have, generally speaking, failed to help. They can, at least, discourage in their clients the expenditure of available funds for mere architectural prettiness, when this quality means the sacrifice of permanence and protection. The *American Architecture*, when it shall have been achieved, will not be known by its mansions so much as by its far more numerous dwellings of modest cost. If low cost houses signify ugly houses, who shall be held responsible, if the tenets of beauty are the cherished secrets of a single profession?

The New York architect refers to the members of the medical profession. When a greater number of the members of the architectural profession have sacrificed their time and their comfort to apply their taste, wisdom and a highly developed sense of beauty to the problems of the poor man, the average man, that his house may be less hideous and more nearly permanent—even as the medical profession has frequently consecrated itself to the poor man, without ample money reward, then will the sincerity of the architectural profession's love of beauty in home architecture go unquestioned.

The permanent house, which is also a thing of beauty and yet within reach of that very large proportion of the American public which are housed now in structures thrice cursed in being unsanitary, unsightly and unsafe,—that house, that particular architectural triumph should command the services not merely of the skilled mechanic and the competent builder, but the service also of the architect. When the abilities of these three shall have been welded into one task, this magazine will not feel called upon to publish the achievements of mechanics and of builders which just miss being real triumphs for the lack of that architectural counsel which should have made them perfect.

A letter from E. B. Murray, Kansas City, Mo., states that though the Kaw River has been at flood height for about 30 das., the concrete revetment described in CONCRETE, Apr., 1915, has sustained no damage.

National League Baseball Park of Reinforced Concrete at Boston

By W. B. Conant[1]

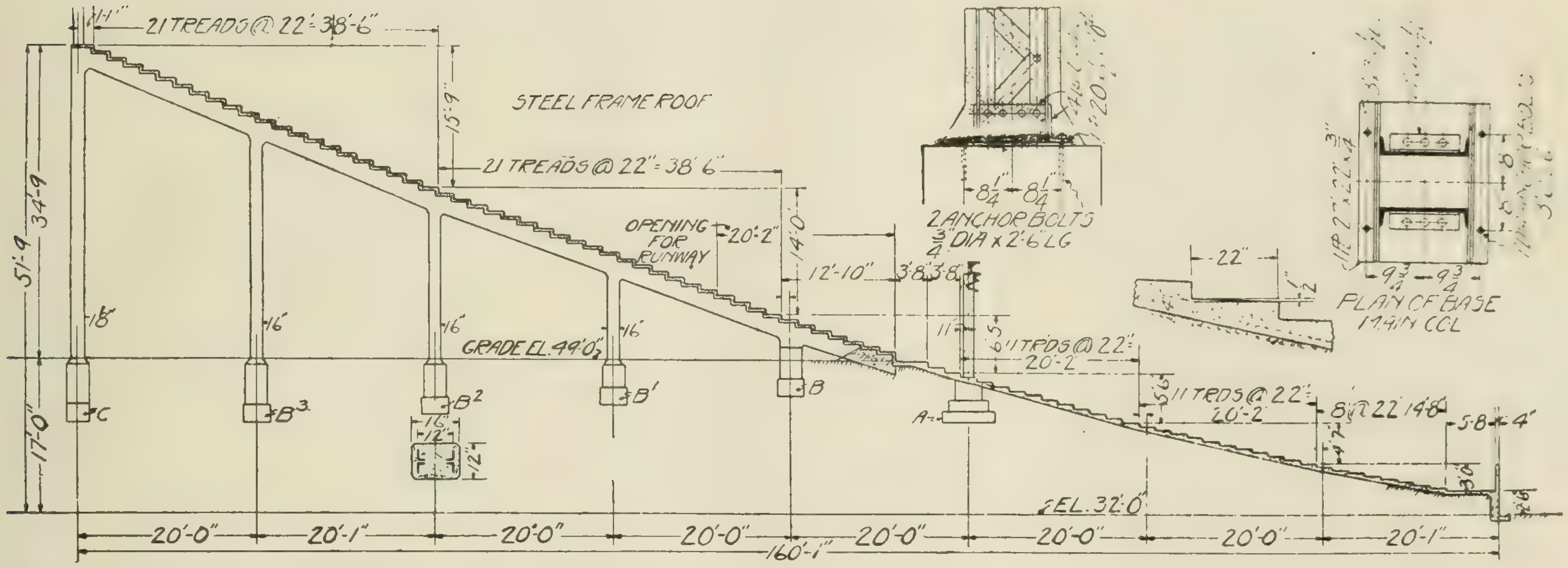

Fig. 1—Section Through Grand Stand Showing Details of Columns

A baseball park, said to be the largest in the world, is being constructed for the Boston National League Baseball Assn., Boston. The land was formerly occupied by the Allston Golf Club as links and is situated in the Allston District between Commonwealth avenue and tracks of the Boston and Albany Ry. It is reached by electric cars from the center of Boston, via the new Boylston street subway, in about 15 min. The park has a seating capacity of 45,000, as compared with 24,400 at Fenway Park, Boston, the grounds of the American League, and 48,000 at the Harvard Stadium at Cambridge, Mass.

All the structures at the Braves' Park, as the new grounds are called, are of reinforced concrete. The structures consist of a three-story office and entrance building, a covered grandstand, two open pavilions, bleachers and a reinforced concrete fence which entirely surrounds the buildings. The area of the property is about 14 acres and of the field enclosed by the spectators' stand 4.5 acres.

GENERAL FEATURES

The office entrance building is 140′ x 40′, the lower floor 18′ high being open on all sides, providing entrance to the spectators' seats through 28 turnstiles, with 12 double ticket booths. The second floor is given to office accommodation and printing plant, and the pitch-roof attic is used for storage.

The first floor is a finished concrete slab, and the second, which covers the open concourse, is a 10-in. slab on which is a layer of asbestos, then 2-in. x 4-in. wood strips, leaving an air-space, then two layers of insulation and 2-in. x 3-in. strips laid at 18-in. centers, with a 7/8-in. maple flooring.

The grandstand and pavilions form the shape of a horse-shoe. The central grandstand is 160′ wide, 480′ long on its inside curve and 700′ long on outside curve, the two extremities forming tangents each 200′

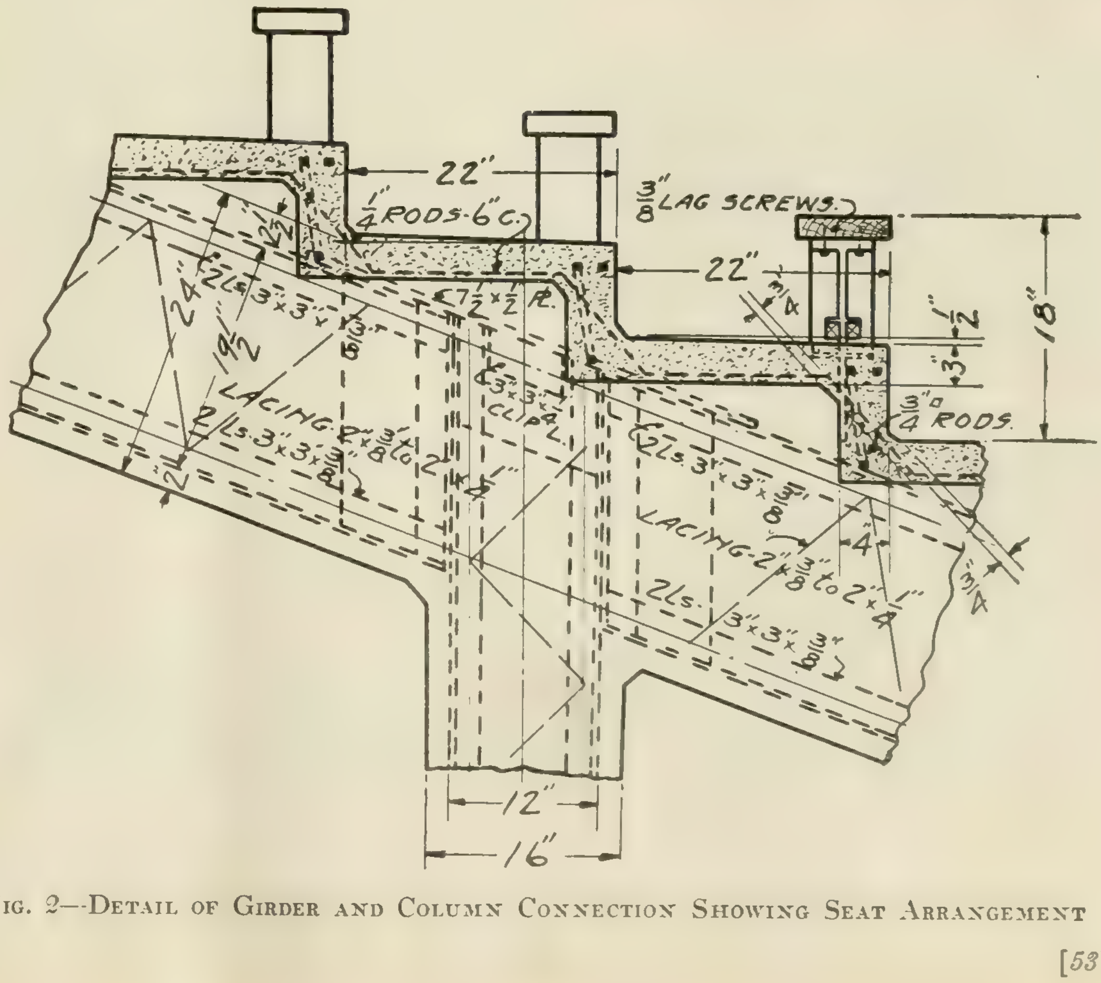

Fig. 2—Detail of Girder and Column Connection Showing Seat Arrangement

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[1] Concord, Mass.

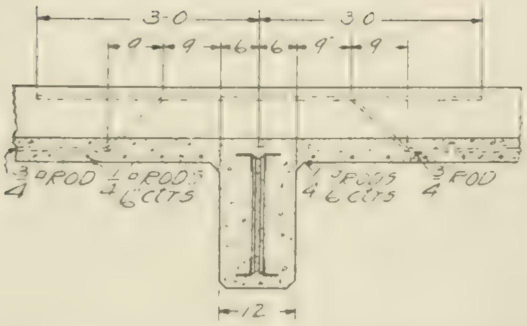

Fig. 3—Longitudinal Section Through Slab and Girder

long. A 25-ft. promenade runs the length of the outer side at the top. At either end of the grandstand is a pavilion, forming practically an extension of that structure. The pavilions are 200′ long and 160′ wide and consist of unbroken lines of steps with rows of seats on each. In all three of these structures the height of the risers increases from bottom to top, thus giving the spectators a better view of the field than if all risers were of the same height.

In the grandstand the risers are from lower to upper rows, 5″, 5½″, 6½″, 7½″, 8½″, 9½″ and 10½″, the increase being at every eighth step. The treads are 2′ 6″ wide. In the pavilions, the risers increase from 4′ 7″ at the lowest to 10′ at the top, and the treads are 22″ wide. The latter all have a ½-in. pitch toward the field.

In the portion of the grandstand that is supported on columns the slab is 3½″ minimum thickness, in the pavilions 3″, and on the ground portion of both structures 4″. The seats provided for the grandstand are Heywood individual chairs, attached to the steps by drilling the concrete and inserting expansion bolts. In the pavilions where plank benches are provided for spectators, cast-iron seat standards were put in position, 4′ apart, before concreting, by fastening them with short screws through their two legs, to the risers of the form, the concrete being leveled to 1″ over the flanged base, the concrete riser edge being 1¼″ from the front edge of the standard. When the forms were removed from underneath, the screws pulled out readily and the spaces around them were dressed.

There are eight entrances to the grandstand by bulkheads through the deck at about midway of the height of the structure, and two ramps 25′ wide leading from ground level to the upper promenade. Each of the pavilions is provided with four entrance bulkheads from beneath as well as a ramp up the side of the structure. The ramps are 5-in. reinforced slabs and beams, supported by columns of the deck structure and by columns underneath.

Over the grandstand is a roof of structural steel columns and girders, wood covering and patent roofing. At the back is a well of terra cotta tiles finished with plaster.

CONSTRUCTION FEATURES

In constructing the grandstand and eastern pavilion, advantage was taken of the sloping character of the ground, so that the lower portion of the deck of each structure rests on a natural gravel bank. Beginning at the eastern end of Pavilion "A," about 50% of the width of the deck rests on this bank, which narrows to a point near the western end of the grandstand, whence the structure continues on girders supported on reinforced columns.

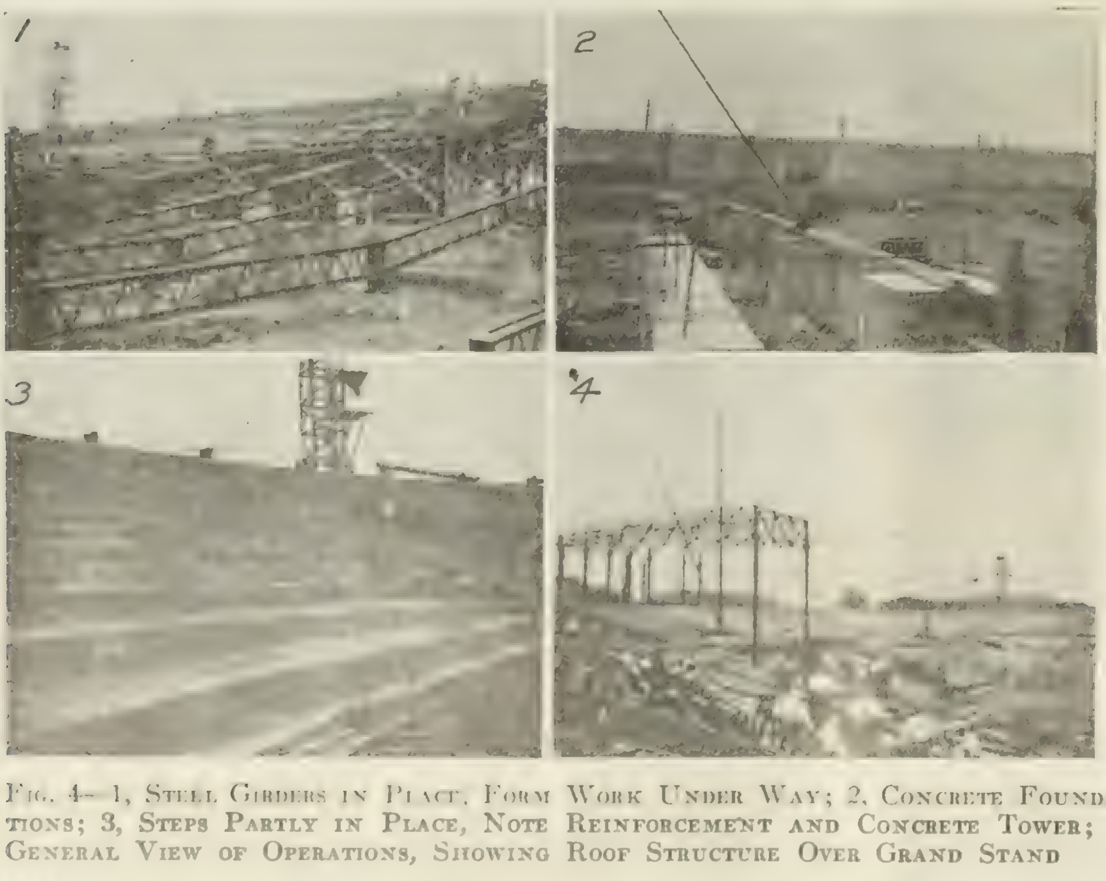

Fig. 4—1, Steel Girders in Place, Form Work Under Way; 2, Concrete Foundations; 3, Steps Partly in Place, Note Reinforcement and Concrete Tower; 4, General View of Operations, Showing Roof Structure Over Grand Stand

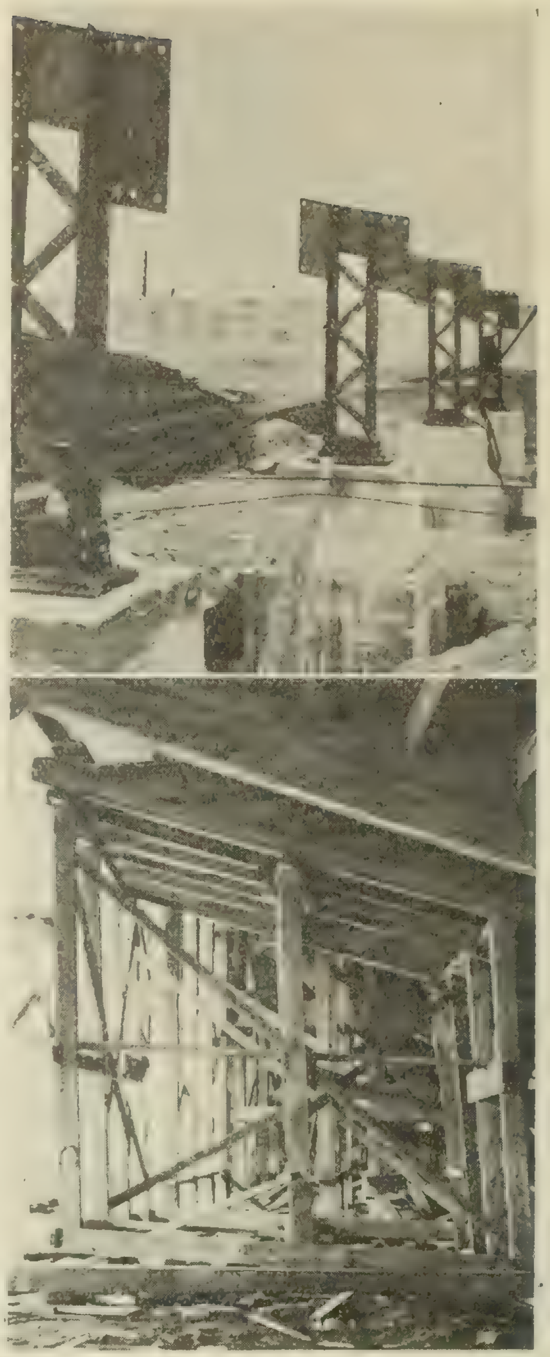

Fig. 5—Steel Columns in Place Ready for Girders and Concrete, Forms for Girders and Steps

The ground was first stripped of its soil, which was piled for use on the ball field, and the bank was graded, leaving the compact gravel undisturbed so as to require no allowance for settling. Three small steam shovels were employed, the earth being hauled by teams to the lower side of the grounds and there deposited to fill a pond and to level the whole field to 19′ above the existing grade along the railroad. Here a retaining wall of reinforced concrete was erected 685′ long, describing an arc with a 2,811-ft. radius, and the usual 12-ft. fence was built upon it.

On the natural earth embankment concrete was poured directly on the ground, 4-in. wire mesh[2] of No. 11 gauge being first laid. Elsewhere, concrete piers and extended footings were sunk in the ground as deep as 20′ to hardpan. These piers carry columns of structural steel encased in concrete and are spaced, in general, 20′ laterally and 13′ 4″ longitudinally. Generally, the outside or rear columns are 15″ x 20″ or 15″ x 18″, and the inner columns are 14″ x 16″ or 12″ x 16″.

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[2] Clinton Wire Cloth Co., Clinton, Mass.

On these columns were erected laced structural steel girders, afterwards concreted to 12″ x 24″, which extend from the ground level up to the top of the rear columns.

Upon these girders, which in the curving portion of the grandstand form converging lines 16′ apart at the rear and 8′ to 10′ apart at the front of the stand, was poured the concrete to form the decks, which consist of the rising tiers of steps already noted.

Construction Plant.—Two Ransome mixers and elevators,[3] with towers 60′ and 75′ high, were used. Concrete was mixed, elevated and discharged into a hopper near the top of the tower, running thence by gravity through a chute to the place of deposit.

The concrete towers used on the job are each of about 250 yds. daily capacity and were erected on temporary tracks adjacent to the work, the tower being moved forward as the pouring progressed. Each mixer and elevator is operated by a 35-h. p. electric motor connected to the local lighting company's power circuits, which were carried through the ground on a temporary pole transmission line.

A field sawmill was operated to cut lumber for forms, the arbor being provided with a rip-saw and a cut-off saw and driven by a 7-h. p. electric motor. About 600 men and 30 to 50 two-horse teams were employed continuously. Two large tents were erected on the ground to quarter the teams.

Forms.—The forms were constructed by nailing together 3-in. x 4-in. and 2-in. x 4-in. spruce joists in the form of horses, with a wooden stair structure on the top, corresponding to the tiers of steps required. The forms were erected in their proper place, in sections, and after concreting were removed, and set up again, being jacked up and wedged in position. The steps were of matched ¾-in. long-leaf Southern pine boards planed both sides.

The next step was the erection of forms to make the risers. These were 2-in. spruce plank, planed one side, and of a width equal to the height of the riser required. Concrete block, cast 3″ x 3″ x 4″, with a ½-in. hole through the center, were used as spacers between the planks and the risers of the form, the two being tied together by rods passing through the plank, concrete block and form risers, and clamped at either end with a Universal rod clamp.[4] The plank was elevated to proper height, so as to allow concrete to be poured for the tread up to its lower edge, by means of a narrow cleat nailed to either end.

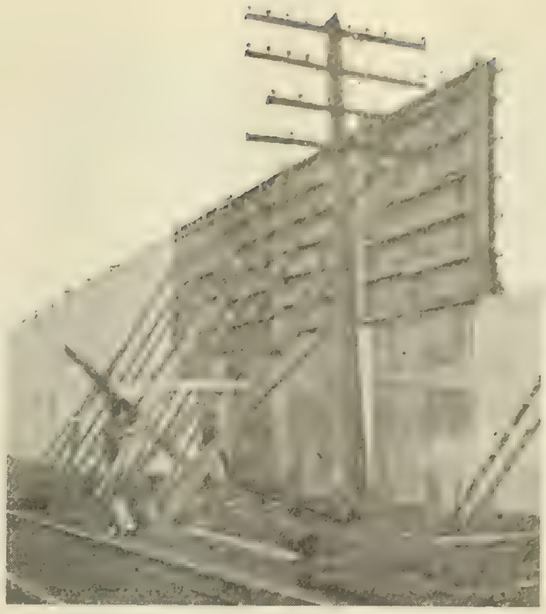

FIG. 6—FENCE UNDER CONSTRUCTION

Reinforcing.—The under frames for a section having been placed, the next step was to lay the reinforcing rods.

Havemeyer deformed bars[5] were used for floors, 1½-in. and ½-in. rods, and for the decks of grandstand and pavilions ¾-in. and ¼-in. longitudinally and ¼-in. rods laterally alternating.

A line of ¾-in. deformed rods was laid longitudinally in the base of each riser, but bent so as to rise about 8″ over the girders where they would be near the top rather than the bottom of the riser, forming a truss support. A second rod, ¼″ in diameter, was laid parallel to the first, at the center of the tread.

The lateral reinforcing is all of ¼-in. deformed rods, laid 6″ apart and bent to the contour of the steps. To do this bending, a foreman on the job devised an adze-shaped wooden hammer consisting of a 6-in. section of 4″ x 5″ oak, attached crosswise by screws to a 4-ft. handle and rounded to form a blunt striking edge. The workman would stand on the rod and strike it a blow at each step to drive it into position, descending as he worked. The cross-rods were wired together at intersections. When concreting the rods were lifted 1″.

Concrete.—In all the construction 1:2:4 concrete was used, composed of Lehigh[6] cement, sharp sand and gravel up to ¾″ or 1″, depending on the structure. Concrete was poured a section at a time, construction joints thus being formed between sections, but no expansion joints were considered necessary. The concreting was begun at the bottom of the section working toward the top to allow run-off of water over completed work, this carrying more or less neat cement to the lower surfaces. As it came from the chute the material was hoed and shoveled into place. Finishers followed and screened and floated the concrete with wood floats, leaving a fairly rough surface, which is deemed a sufficient provision against slipping.

The 12-ft. fence which surrounds the park is well shown in the illustrations. The fence posts are reinforced with four 1¼-in. rods. Posts are at every 12′, and every fourth post has an expansion joint filled with two layers of tar felt. Throughout the fence are ¼-in. vertical rods on 12-in. centers.

The fence was rubbed over to remove form marks. All the concrete columns, and the outer walls of the building, were given a 1:2 finish coat.

Earth removed amounted to about 85,000 yds., and concrete poured, about 10,000 yds. In the grandstand are about 750 tons of structural steel,[7] and in both pavilions 250 tons. The total cost of the construction approximates $400,000.

PERSONNEL

The contractors are the James E. Gaffney Cont. Co., N. Y. C., James E. Gaffney, its head, being President of the Boston Natl. Baseball Assn., proprietors of the Boston team and owners of the park property. The engineer of construction was R. G. Collins, Jr. The Osborn Engrg. Co., Cleveland, were the architects.

Work was begun Mar. 22, and it is expected that the park will be opened for League games by Aug. 15, 1915.

Completing New Freight House at Panama

The roof over the south wing of the new concrete freight house of the Panama railroad for the city of Panama is finished and the final plastering of the walls of hollow concrete block, and the painting of the roof trusses are in progress. The entire building is 75′ x 600′ in plan, with a two-story section in the center 40′ long, the upper story of which is used for offices, and, after allowing for depressed tracks occupying a width of 12′ for practically the length of the building, affords about 36,000 sq. ft. of storage space in addition to the office space. —*Canal Record.*

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[3] Ransome Concrete Machy. Co., Dunellen, N. J.

[4] Universal Form Clamp Co., Chicago

[5] Concrete Steel Co., N. Y. C.

[6] Lehigh Portland Cement Co., Allentown, Pa.

[7] New England Structural Steel Co., Everett, Mass.

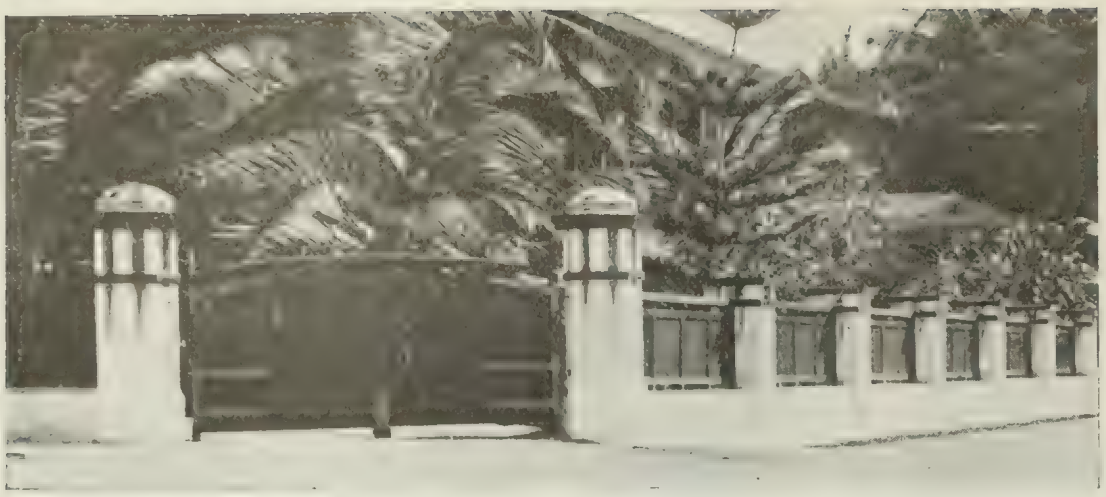

FIG. 1—UNIQUE CONCRETE FENCE IN PORTO RICO

An Unique Concrete Fence as Constructed in Porto Rico

While this artistic concrete fence has its ideal setting among the waving palms and tropical environments afforded by Porto Rico, it has a suggestive value that may well be considered by any one who has the opportunity to design a similar piece of work.

The illustrations render extended description superfluous but the following notes contributed by Earl K. Burton[1] are interesting.

The posts were cast in forms of 1-in. dressed lumber. The line posts are hollow and were cored by means of a tapered wood form which was removed before the top slab was cast. This hollow is filled with earth and in it flowering vines will be planted to drape over the post. The corner posts are lanterns for the gateway and are glazed with leaded green glass and the posts are surmounted by a leaded cathedral glass domes. Light is supplied by four electric bulbs in each lantern.

Each post is ornamented by two mahogany bands, fastened to the concrete by brass bolts. The panels are also of mahogany, the palings being ⅞" x 1¾" and spaced ⅞" apart. The combination of the mahogany and the gray of the posts is very pleasing. The decorative panels in the posts are of colored faience tile set into recesses left in the posts when cast, so that the mosaic is flush with the surface.

The concrete is made of ¾-in. blue trap-rock, sand and cement mixed 1:2½:5, and left rough for plaster finish. Four ½-in. rods were used to reinforce each post. The finish is a ⅜-in. coat of mortar, cement and sea sand mixed 1:2.

Some methods that seem peculiar were used in finishing. The plaster coat was put on and hand-floated. It was then dusted with dry cement while green and finished very smooth. After troweling the surface was worked over with a damp camel's hair brush to improve the surface and to prevent hair cracks. The contractor explains that the brushing "opens the pores and lets the cement breathe."

The Porto Rican masons do not use a plasterer's trowel, but do all their work with a pointed trowel and it is remarkable that they are able to secure a smooth and true surface with this tool.

The design is by Antonin Nechedoma, archt., and the work was done by F. B. Hatch, contractor, San Juan, P. R.

EDITOR'S NOTE

While the surface treatment described would produce a very fine effect, and the brushing undoubtedly reduces the liability to hair cracks,

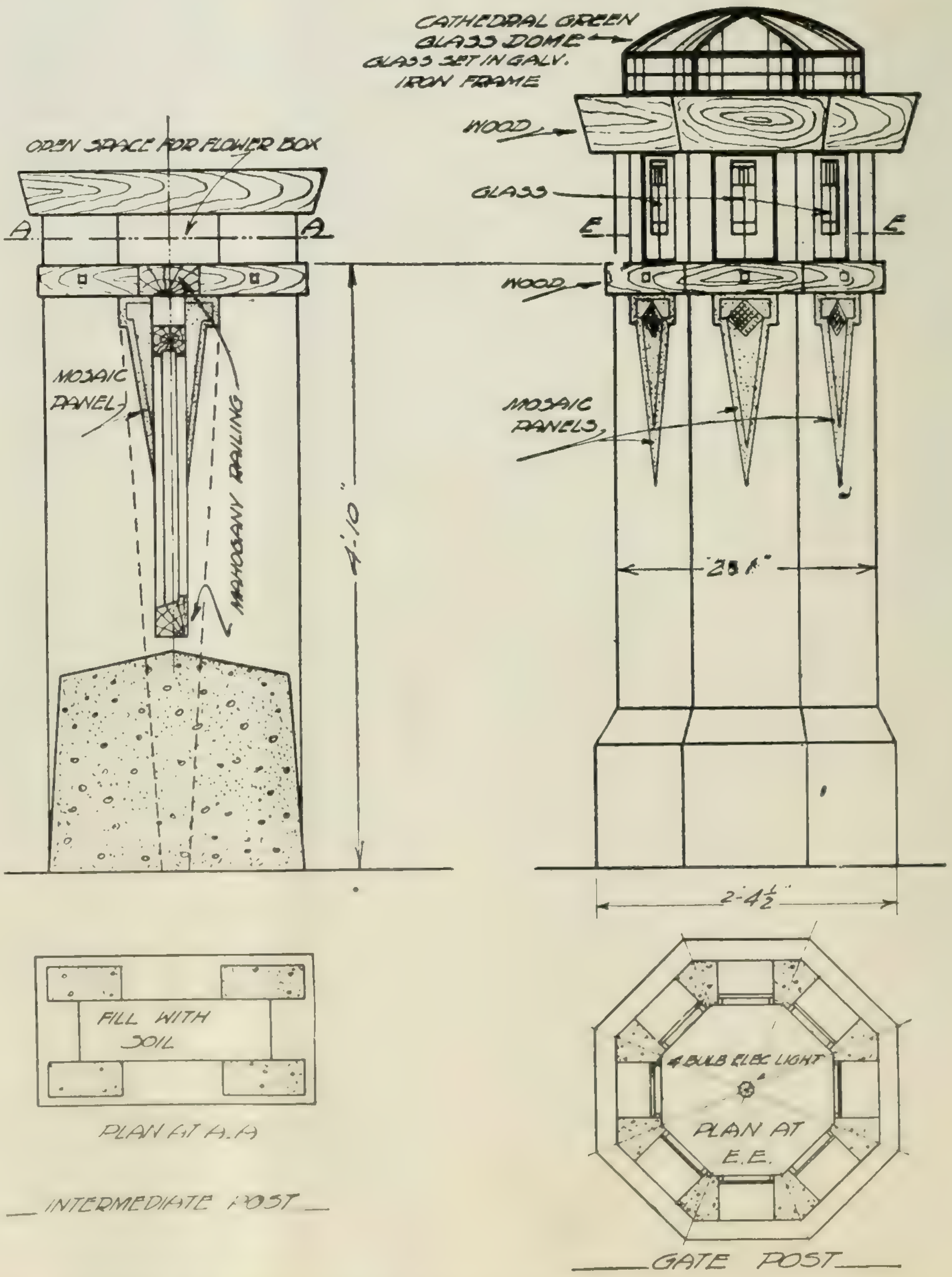

FIG. 2—DETAILS OF CONCRETE GATE AND LINE POSTS

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[1] Res. Engr., Trussed Concrete Steel Co., San Juan, Porto Rico

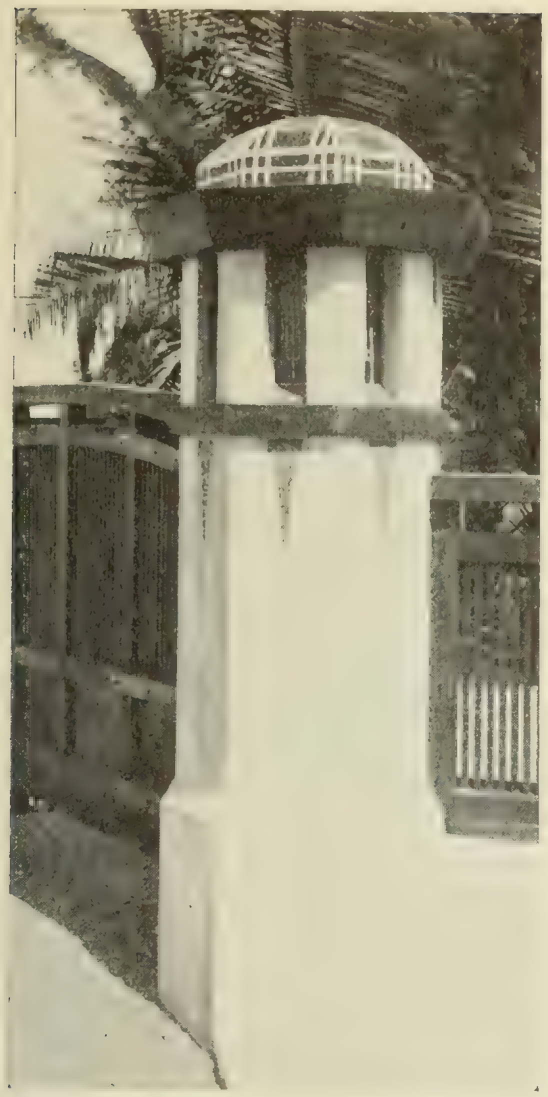


Fig. 3—Detail of Gate Post and Lantern

Note inlaid tile mosaic and mahogany bands

we seriously question the application of dry cement to the surface and the excessive troweling that this method indicates. This is truly a beautiful piece of work and we sincerely hope that the contractor's confidence in the permanence of this finish will be justified.

At the Massachusetts General Hospital concrete work has been selected as a means of employment and encouragement to invalids who are prevented from following their usual employment while not yet entirely incapacitated. A first-class shop has been put into operation, tools, molds, etc., have been provided. It is found that the work requires very little, if any, special training and that with proper direction and suitable molds it can be done by any person of ordinary intelligence. The articles made include flower boxes, bowls for bulbs, garden benches, stepping stones, pedestals and garden vases. These are sold to make the department self-supporting and while many of them are of beautiful designs they are sold at low prices because they are made without technical skill and by people who could not compete in the open market.

Some Standard Designs for Concrete Form Work

From the standard construction of concrete forms as used by the Newport News Shipbuilding and Dry Dock Co.,[1] we are indebted to Godfrey L. Smith, C. E.

The drawings are self-explanatory but special attention is called to the nailing of sheathing boards. The nailing next the concrete is with as small nails as practicable for easy wrecking and outside nails are provided with collars[2] to permit their easy removal.

The rat evil which has caused so much trouble in New Orleans is being rapidly abated by the rat-proofing ordinance which provides methods for wiping the rodents out of existence. New Orleans is passing through her great reconstruction period and since the outbreak of a few bubonic plague cases more than a year ago, 50,000 residences, business houses and public buildings have been rat-proofed and there are many more to follow. The work was done under peremptory ordinances which the property owners contested in the courts. The Supreme Court only recently has upheld the right of the state and the city to order the work done upon the general ground of the police power of the municipality to protect its citizens from danger.

High Mixing Run at Panama

Seven hundred seventeen cu. yds. of concrete were placed by the Division of Terminal Construction Thursday, June 17, in a large monolith in the north wall of dry dock No. 1 at Balboa, near the entrance, by two ½-yd. cube mixers. The combined number of mixer-hours for the two mixers was 15½, giving an average amount of concrete per hr. per mixer of 46.2 cu. yds. One of the mixers was on the south wall of the dry dock, and was operated under the supervision of General Foreman M. N. Lenham, and the other was on the north side of the entrance pier, and was under the supervision of Foreman W. L. Green.

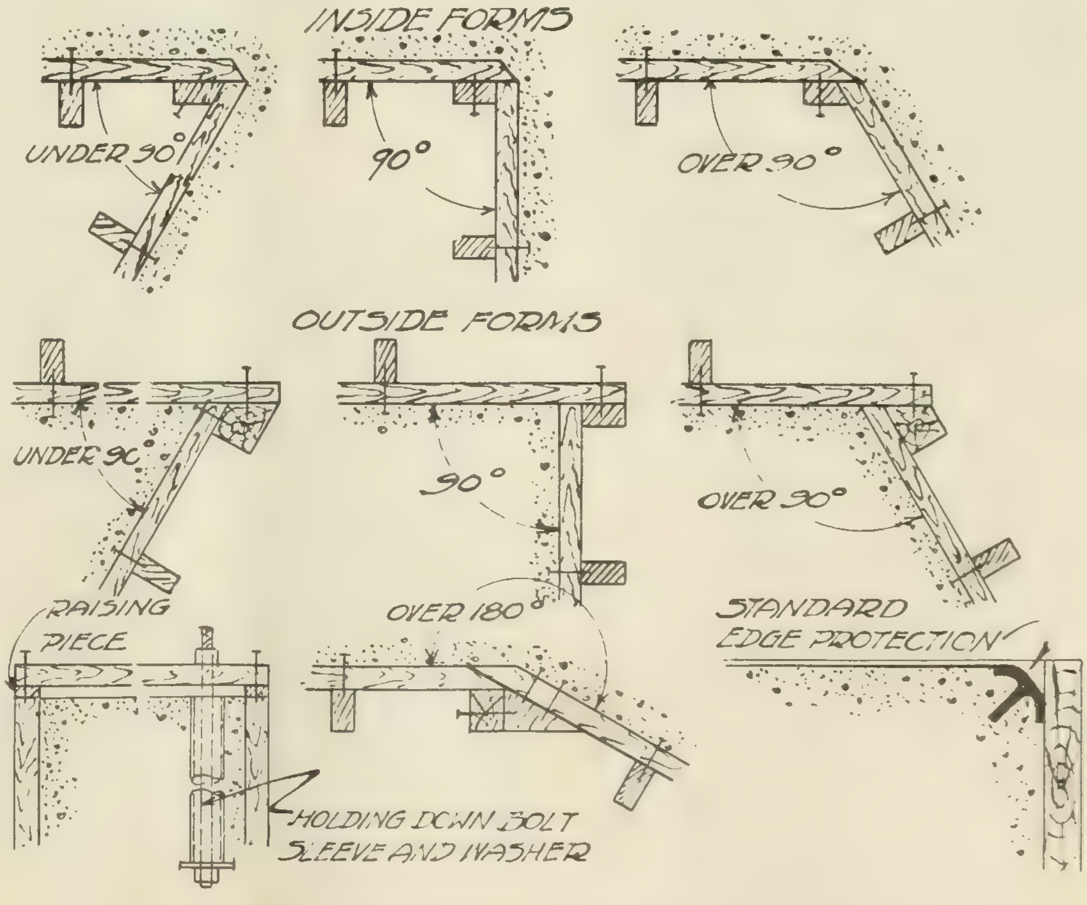
The total labor cost, including supervision, for operating the two mixers mixing the concrete was $67.27, making the total labor cost per yard for mixing 9.4 cts.—*Canal Record.*

A Waterproofing for Concrete

The following wash is recommended as effective waterproofing for cisterns, silos and similar structures. A stock solution is made of 1 lb. lye, 5 lbs. alum and 2 qts. water.

A pt. of this solution is added to a bucket of water and 10 lbs. of cement, making a paint-like mixture to be applied with a brush.

This is a modification of the well known Sylvester process and depends on the precipitation within the pores of the concrete of insoluble alum soap or alumina hydrate, or both together.



Standard Forms Used By Newport News Shipbuilding & Dock Co.

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[1] Newport News, Va.

[2] Wagner-Behm Co., Chicago

Building Concrete Silos—Monolithic Construction—Types of Commercial Equipment

By C. D. Gilbert

This is the second of two articles by Mr. Gilbert on concrete silo construction. The article last month described the use of various types of unit construction with block and staves. It also considered various features which are common to all silo construction and these are only touched upon in the present article, which considers monolithic construction.

Any article dealing with monolithic silo construction must of necessity be devoted in part to commercial silo equipment.

It is possible to make home-made forms with which to build good silos and there are numerous pamphlets telling how.[1]

Home-made forms may be reasonably efficient and will, if well made, serve in building several silos, but they are not to be recommended for the use of the silo contractor, as the commercial steel forms are much less likely to give trouble in building silos year after year. With these forms a great deal of time can be saved in raising and placing, and work is true to size, and perpendicular. A number of forms are on the market which vary considerably in construction.

Fig. 1 shows a steel silo equipment in detail.[2] This type suspends forms staging and all apparatus from a heavy steel center mast. Sturdy lever jacks bearing on a casting pinned to the mast easily lift the entire form structure in a few minutes.

Other equipment provides for the use of two complete sets of forms which are alternately raised above one another and supported partially by the silo wall[3] (Figs. 2 and 3).

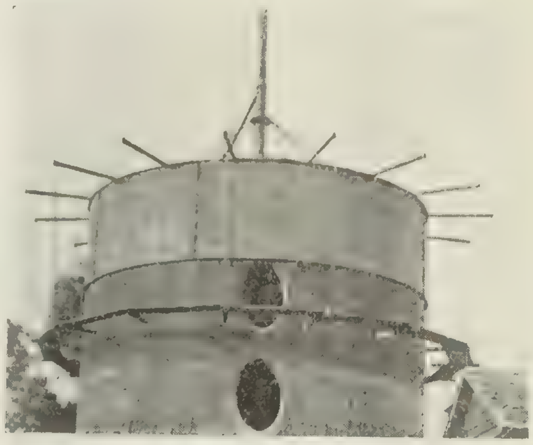

Fig. 1—Center Mast Type Silo Forms

Note suspended staging and special oval doors

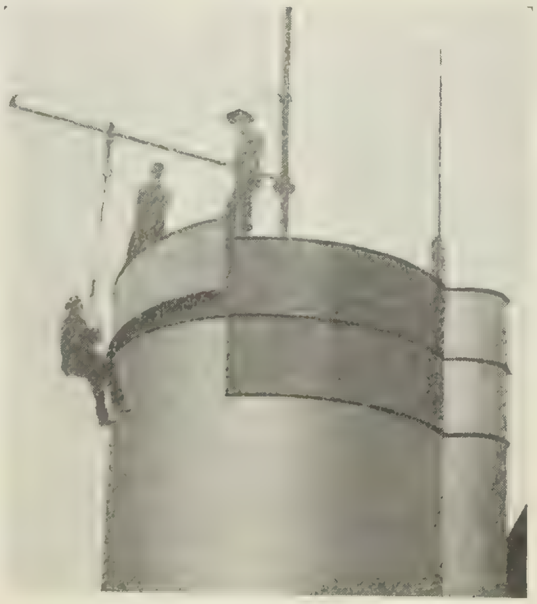

Fig. 2—Two Section Forms of Center Mast Type

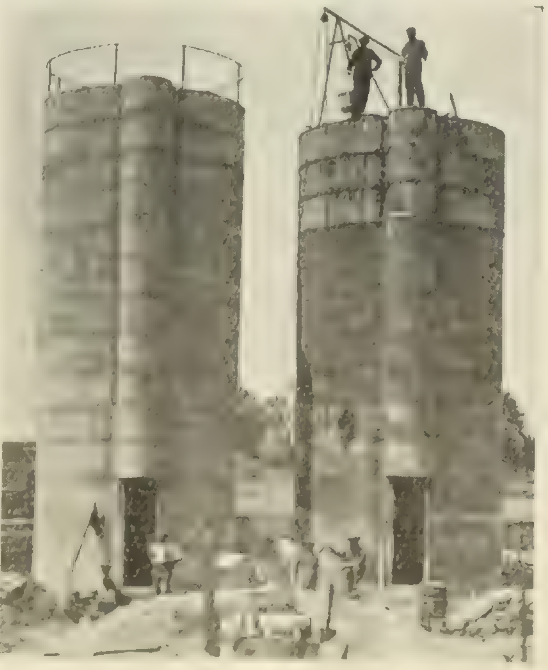

Fig. 3—Two Section Forms. No Center Mast

Most forms are built to erect silos of one diameter only, but as shown in Fig. 4, equipment is available which can be adjusted for various sizes.[4] All these forms are arranged so that a concrete chute can be cast as a monolith with the silo at little extra cost.

There is no doubt that the monolithic silo built of first-class concrete upon an adequate foundation is the last word as a permanent structure. Its shape is ideal for maximum resistance to deterioration and as the construction used admits of the best of material placed and reinforced so as to develop its maximum efficiency, the only limit to height is that imposed by the use to which the structure is put.

Fig. 7 shows an entirely different type of silo equipment—a machine with which to build either a single or double wall.[5] Walls can be erected 3′ to 4′ high per da. The simplicity of the equipment and the possibility of a frost-proof wall appeal to many builders.

THE HIGH SILO

With modern equipment it costs little more to build a given amount of wall high in air than to build it near the ground. Therefore, as it is a well known fact that the higher the silo, the greater the tonnage per cu. ft., the economy of the high silo is evident. On account of the increased pressure a 60-ft. silo will hold twice as much as a 40-ft. silo, because of the added pressure which compacts the silage and better excludes the air. It will also produce a better quality of feed. The price per ton capacity in very tall silos is remarkably low.

LOCATION

While the builder does not usually choose the location of the silo, his experience should enable him to give valuable counsel to the farmer for whom he builds, especially to the man who is building for the first time, and consequently does not take

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[1] Among available publications are: Bulletin 586, U. S. Dept. of Agriculture and publications of several State Experiment Stations, the Assn. of Am. Portland cement Mfrs. and the Universal Portland Cement Co.

[2] Polk-Genung Co., Fort Branch, Ind.

[3] Conklin Const. Co., Hartford, Mich., and New Enterprise Concrete Machy. Co., Chicago

[4] Reichert Mfg. Co., Milwaukee, Wis.

[5] Van Guilder Hollow Wall Co., Rochester, N. Y.

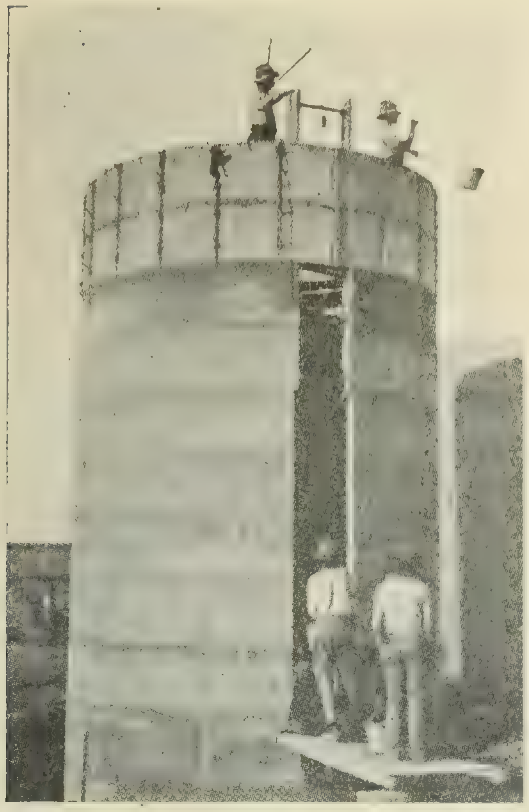

Fig. 4—Sectional Forms Adjustable to Size

into consideration all the points involved.

While the foundation must in all cases go below frost and if necessary to reach solid ground go to considerable depth, the floor of the silo should be no more than 4′ to 6′ below ground. It is no joke to throw the last heavy silage out of a deep pit.

Unless planned for field feeding, the silo should be close to the barn and connected with it by an enclosed alley leading directly to the mangers. Usually a car on rails, or better, on an overhead track, is arranged to take the ensilage direct to where it is fed. The silo should be so located that the ensilage cutter can be placed easily and reached by the teams at filling time and an opening provided in the roof at a point most convenient for filling. It is seldom good practice to put a silo in the barn, both on account of the space it occupies and because it is usually difficult to reach for filling.

DRAINAGE

If the silo is so located that water would ordinarily rise above the level of the floor, an outside drain should be provided. There seems to be some difference of opinion as to the value of a drain from the inside of the silo. Under ordinary conditions corn silage does not release a great amount of surplus water. Cases are on record, however, where from special conditions at filling or where some crop other than corn was used for silage, an excess of water was present which subjected the silo to excessive pressure and in rare cases caused failure. It seems wise, therefore to provide a drain properly trapped (Fig. 7).

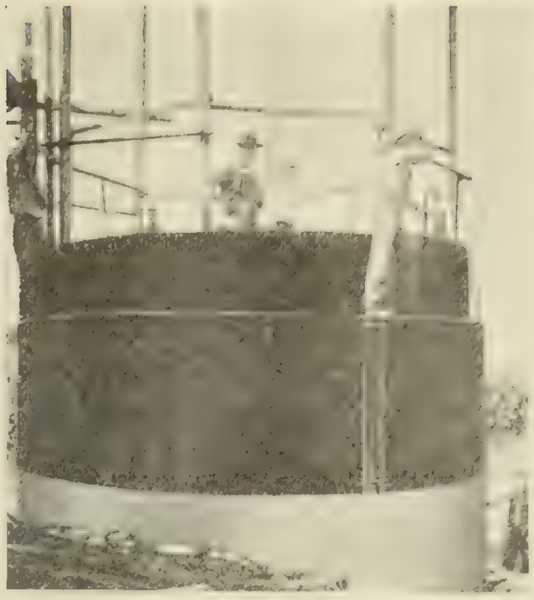

Fig. 5—McCoy[6] Steel Forms Supported from Staging

MATERIALS AND PROPORTIONS

The proper proportioning of materials opens a question in which it is difficult to be specific and where generalization is unsatisfactory. Clean bank or river sand and gravel are most often available. Stone larger than 1″ should be removed and unless sand and gravel are found in very nearly correct proportions it is economical to screen and reproportion. It is needless to say that sand and gravel must be entirely free from loam or clay. If materials are of good quality with a proper proportion of coarse gravel, 1:6 will be a satisfactory proportion to use, considering 6 as representing the volume of mixed sand and gravel. With finer material 1:5 is better. The mixture should be such that a smooth, dense wall will result.

Very thorough mixing is important and for this reason, if no other, a machine is to be preferred to hand mixing. The consistency should be "quaky," not sloppy. The concrete should work easily and thoroughly into place, but contain no free water. After all, experience is the only reliable guide, and exact proportions from specifications are to be taken in the light of practical experience. See Table No. 1 for quantities of material.

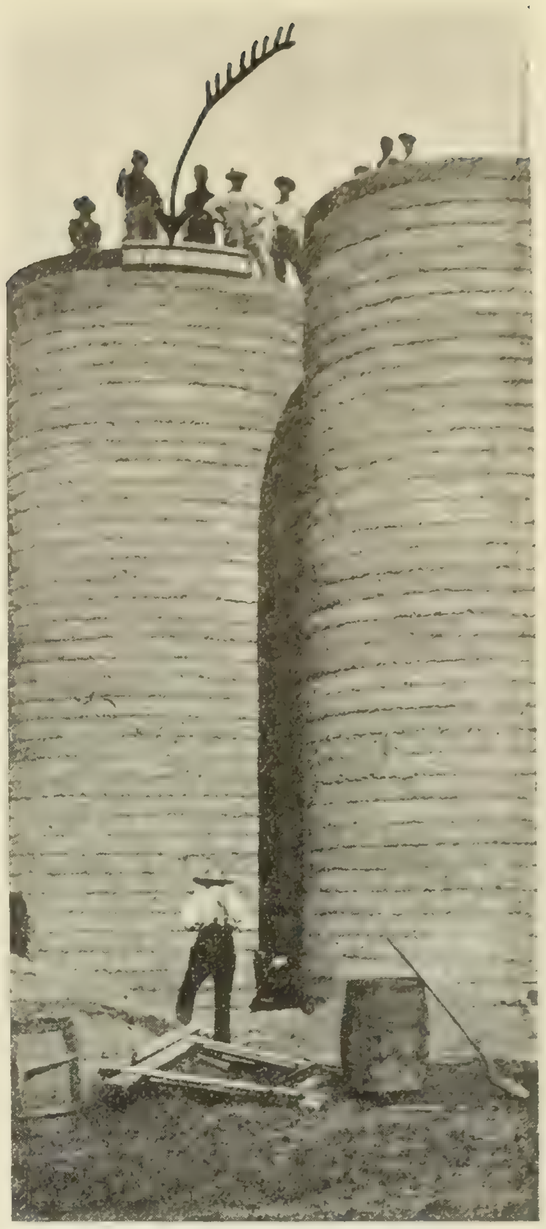

Fig. 6—Silo Building Machine
Erects single or double wall

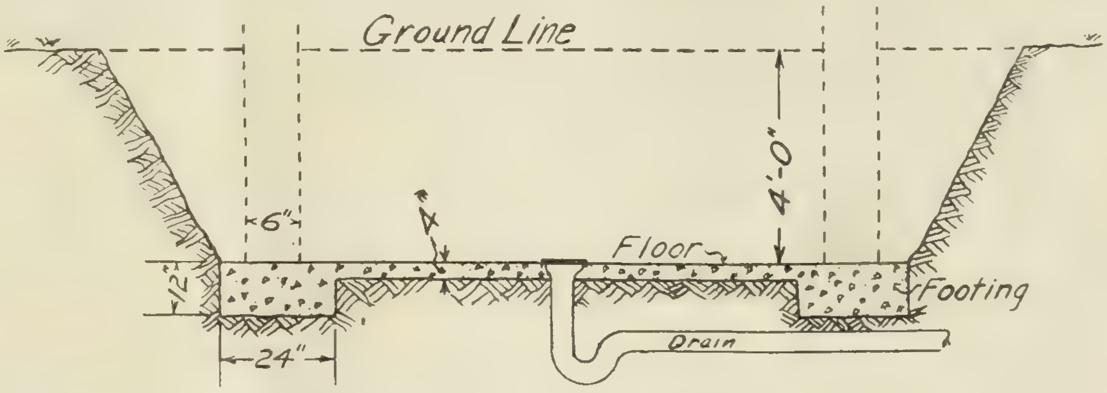

Fig. 7—Diagram of Silo Foundation Showing Drain

BUILDING THE WALL

The exact methods to be used vary slightly with the forms used and as every form manufacturer furnishes full directions for their use, and most of them send out men to start the work, this article is devoted to a discussion of other details.

HOISTING MATERIALS

Most of the commercial forms are arranged with a suitable device for raising concrete, the power being either a horse or a mechanical power hoist, the latter generally combined with the mixer.

This method is most satisfactory. If for some reason hand power must be used a home made hoist,[7] illustrated in Figs. 8 and 9, is easily made and surprisingly effective.

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[6] McCoy Silo Form Co., Pittsburgh

[7] See Concrete, Apr., 1914, p. 200

TABLE 1—AMOUNT OF CONCRETE MATERIALS FOR COMPLETE SILOS OF VARIOUS DIAMETERS (INSIDE)

These figures include footings and floor, but not roof. Walls 6″ thick. Continuous doors 2½′ wide. Figures are for bbls. of cement and cu. yds. of sand and gravel.

Height of Silo in Feet	Cement	Sand	Stone	Cement	Sand	Stone	Cement	Sand	Stone	Cement	Sand	Stone	Cement	Sand	Stone	Cement	Sand	Stone			
		8′ diam.			10′ diam.			12′ diam.			14′ diam.			16′ diam.			18′ diam.			20′ diam.	
20	16.5	5.1	10.2	21	6.5	13.0															
22	17.9	5.5	11.0	22.7	7.0	14.0															
24	19.2	6.0	12.0	21.5	7.5	15.0	29.6	9.1	18.2												
26	20.5	6.3	12.6	26.1	8.0	16.0	31.7	9.8	19.5												
28	21.9	6.7	13.4	27.1	8.5	17.0	33.8	10.4	20.8	39.8	12.2	24.4									
30	24.2	7.1	14.2	29.7	9.0	18.0	35.9	11.0	22.0	42.3	13.0	26.0									
32				31.2	9.6	19.2	37.9	11.6	23.2	44.7	13.7	27.4	51.3	15.9	31.8						
34				32.9	10.1	20.2	40.0	12.2	24.4	47.1	14.4	28.8	54.3	16.7	33.4						
36				34.6	10.5	21.0	42.1	12.8	25.6	49.4	15.1	30.2	57.1	17.5	35.0	64.8	19.9	39.8			
38				36.4	11.1	22.2	44.0	13.4	26.8	51.9	15.8	31.6	59.8	18.3	36.6	67.9	20.8	41.6			
40				38.1	11.5	23.0	46.2	13.8	27.6	54.3	16.5	33.0	62.6	19.1	38.2	71.0	21.7	43.4	79.4	24.3	48.6
42							48.3	14.7	29.4	56.7	17.3	34.6	65.3	19.9	39.8	74.1	22.6	45.2	82.9	25.3	50.6
44							50.3	15.3	30.6	59.2	18.0	36.0	68.1	20.8	41.6	77.2	23.6	47.2	86.3	26.4	52.8
46							52.4	15.9	31.8	61.5	18.7	37.4	70.8	21.6	43.2	80.3	24.5	49.0	89.8	27.4	54.8
48							54.4	16.5	33.0	63.9	19.4	38.8	73.7	22.4	44.8	83.5	25.4	50.8	93.3	28.4	56.8
50							56.5	17.1	34.2	66.3	19.9	39.8	76.4	23.2	46.4	86.6	26.3	52.6	96.7	29.5	59.0

NOTE—For simplicity the amounts given above apply to silos with continuous doors. If intermittent doors are used, slightly greater amounts of material will be needed. The above table is based on a proportion of 1:2:4 for the walls and 1:2½:5 for the floor and footings—Courtesy Assn. Am. Portland Cement Mfrs.

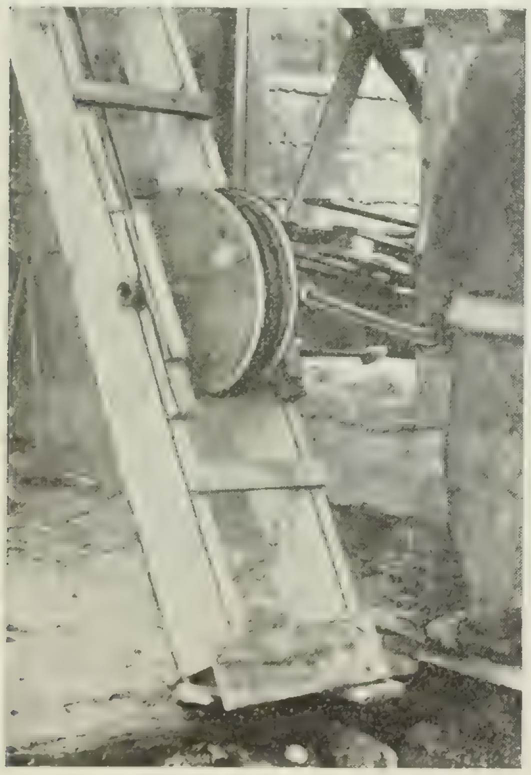

FIG. 8—HAND HOIST IN USE

DOOR FRAMES AND DOORS

Silo form makers have worked out a number of good door construction details. Both continuous and separate doors are advocated.

Considering convenience, general satisfaction and economy, the experience of many silo builders and recommendations of experiment stations seem to favor a continuous doorway with wood doors bearing on a concrete jamb.

Fig. 10 shows simple form work detail for building the doorway.[8]

CHUTES

The concrete chute cast with the silo is the most usual and no doubt the best construction.

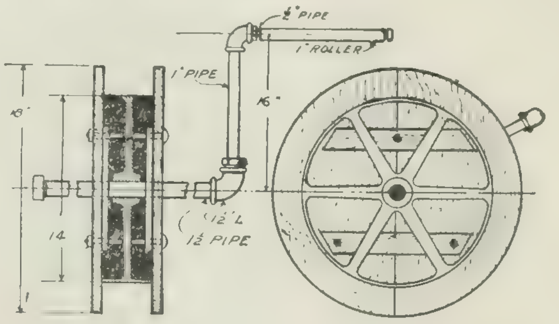

FIG. 9—DETAILS OF HOMEMADE HOIST

Where the forms are not arranged for chute building, a wood chute can be bolted to the silo or, better, a chute now on the market made of heavy corrugated iron[9] can be used. Wood or metal chutes are to be considered more as an addition to a silo already built than as first-class construction on new work.

The top of a continuous doorway should be carefully bridged with a concrete beam, particularly where a tank is to be constructed. The beam is the thickness of the wall and at least 12″ deep. In general, where a tank is used, ½-in. rods 4′ long should be placed in this beam.

REINFORCING FOR CONCRETE SILOS

As has been repeatedly said, the one great requirement for a successful concrete silo, given good concrete, is proper and sufficient reinforcing.

Ernest McCullough, C. E., says in an article describing in detail the methods of figuring silo reinforcement[10]:

> The pressure against the wall of a silo is converted into tension in the circumference tending to burst the wall.
>
> It is convenient to use fluid pressure as a measure of force against the sides of tanks, retaining walls, etc., and the pressure per sq. ft. at any depth is equal to the depth multiplied by the weight per cu. ft. of the fluid. For example, water weighs 62.5 lbs. per cu. ft., and the pressure per sq. ft. at a depth of 20′ is equal to $62.5 \times 19.5 = 1{,}220$ lbs., the 19.5′ representing the depth to the center of gravity of the cu. ft. of water at the depth of 20′.
>
> Fine, dry sand exerts a pressure equivalent to a fluid weighing 32 lbs. per cu. ft.; dry, loose gravel exerts a pressure equivalent to a fluid weighing 25 lbs. per cu. ft., and ensilage exerts a pressure equivalent to a fluid weighing 11 lbs. per cu. ft.

This explains the following simple formula furnished by the Kans. Agr. Exp. Sta.:

> To find the pressure per sq. ft. for any point in a silo wall, when filled with silage, multiply the distance in feet from the top of the silo by 11, and this result by one-half the diameter of the silo. Example: The pressure per sq. ft. at the bottom of a silo 16′ in diam. and 40′ high will be, $40 \times 11 \times 8 = 3{,}520$ lbs. This pressure must be sustained by the reinforcing. By referring to Table 2 the amount of wire or rods necessary to sustain the load at various heights can be calculated.

TABLE 2—SAFE LOADS FOR REINFORCING

Gauge No.	Lbs.	Gauge No.	Lbs.	Gauge No.	Lbs.
0	1,480	6	579	12	173
1	1,258	7	492	13	133
2	1,086	8	412	14	100
3	935	9	364	15	81
4	795	10	286	16	62
5	673	11	226	..	..

SAFE LOAD FOR ROUND STEEL RODS

Diam. of rod in in.	Lbs.	Diam. of rod in in.	Lbs.
1	12,576	½	2,540
⅞	9,620	⅜	1,766
¾	7,069	¼	785
⅝	4,908	⅛	196

SAFE LOAD FOR SQUARE STEEL RODS

Size in in.	Lbs.	Size in in.	Lbs.
1	16,000	½	4,000
⅞	12,249	⅜	2,249
¾	9,000	¼	1,000
⅝	6,249	⅛	196

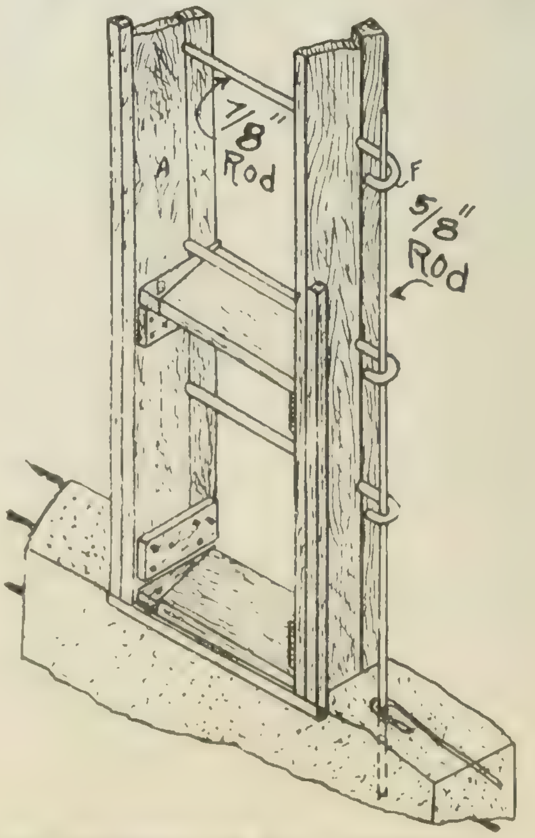

FIG. 10—FORM FOR SILO DOORWAY

Note strips to form rabbet and that forms are split to allow removal from ladder rods

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[8] See also CONCRETE, July, 1915, p. 4, for door construction

[9] Kalamazoo Tank & Silo Co., Kalamazoo, Mich.

[10] *Concrete*, Apr., 1911, p. 32

Am. Steel and Wire Co., Triangle Mesh Concrete Reinforcement Safe load per sq. ft. is as follows:

Style 7.... 820 lbs.
Style 23....3,400 lbs.
Style 25....2,480 lbs.
Style 27....1,700 lbs.
Style 31....5,220 lbs.
Style 32....4,500 lbs.
Style 33....3,920 lbs.
Style 42....3,020 lbs.
Style 28....1,320 lbs.

Table 3 gives the proper amount of horizontal reinforcing where rods are to be used. Many builders prefer woven wire reinforcement of the type shown in Fig. 11, or heavy hog fencing is often used. In large silos the woven reinforcing should consist of double fencing below 35′ from the top. Many extremely high silos are now being built and while it is conceded that on account of friction there is a point at which the pressure does not increase, that point is probably not reached in silos less than 50′ high and structures above that height should be carefully designed, taking into account individual conditions.

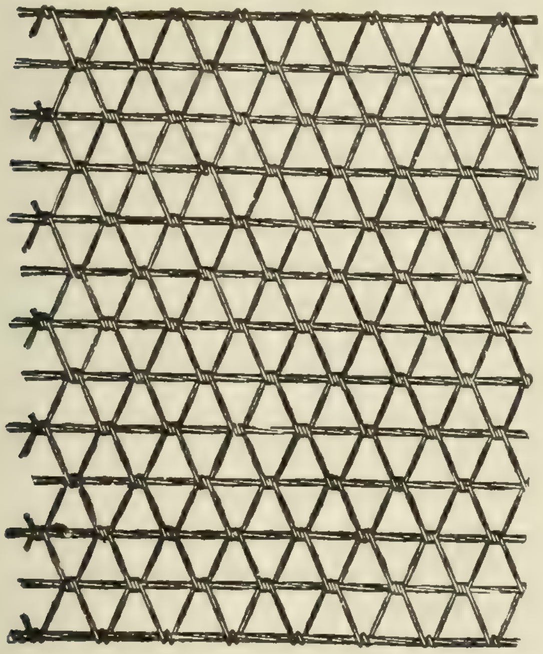

Fig. 11—Triangle Mesh Reinforcing

Vertical reinforcing is not considered really necessary except at the doorway in silos under 35′ or 40′. It is, however, convenient as a support for horizontal reinforcing. The higher silos should carry vertical reinforcing to resist wind pressures.

When rods are used as reinforcing various special devices can often be used economically in securing them in place, such as clips which can be snapped on quickly or a special tool that wires the intersections rapidly.

The heavier horizontal bars should be hooked together or coupled with cable clips or similar device, while

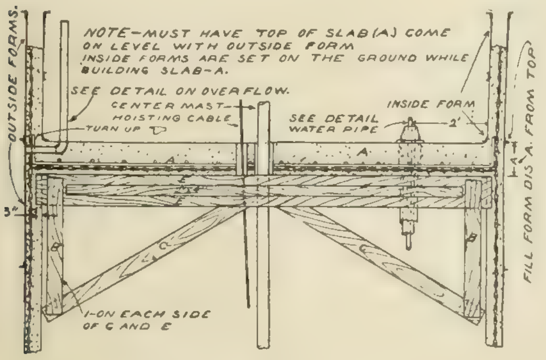
OUTSIDE FORMS.
NOTE—MUST HAVE TOP OF SLAB (A) COME ON LEVEL WITH OUTSIDE FORM
INSIDE FORMS ARE SET ON THE GROUND WHILE BUILDING SLAB-A.
SEE DETAIL ON OVERFLOW.
CENTER MAST
HOISTING CABLE
TURN UP
SEE DETAIL WATER PIPE
INSIDE FORM
2′
A
A
E
B
C
3″
1-ON EACH SIDE OF C AND E
FILL FORM DIS A. FROM TOP

Fig. 12—Form for Tank Floor

Table 3—Horizontal Reinforcing Bars for Silos of Various Inside Diameters

Distance in Feet Down from Top	8′	10′	12′	14′	16′	18′	20′
of Silo	¼″ Bars	¼″ Bars	⅜″ Bars	½″ Bars	½″ Bars	½″ Bars	½″ Bars
Top to 5′	24″	24″	24″	24″	24″	24″	24″
5′ to 10′	15½″	12″	24″	24″	24″	24″	24″
10′ to 15′	10½″	8½″	16″	24″	20″	19″	17″
15′ to 20′	7½″	6½″	12″	18″	16″	14″	12″
20′ to 25′	6″	5″	9½″	14″	12½″	11″	10″
25′ to 30′	5″	4″	8″	12″	10½″	9½″	8½″
30′ to 35′		3½″	7″	10½″	9″	8″	7½″
35′ to 40′		3″	6″	9″	8″	7″	6½″
40′ to 45′			5″	8″	7″	6″	5½″
45′ to 50′			4½″	7″	6½″	5½″	5″

From Bul. *Concrete Silos*, Assn. of Am. Portland Cement Mfrs.

Table 4

Longitudinals Spaced 4-in. Centers Cross Wires Spaced 4-in. Centers
Number and Gage of Wires, Areas Per Ft. Width and Weights Per 100 Sq. Ft.

Style Number	Number of of Wires Each Long	Gage of Wires Each Long	Gage of Cross Wires	Sectional Area, Long, Sq. Ins.	Sectional Area Cross Wires, Sq. Ins.	Cross Sectional Area, Per Ft. Width	Approximate Weight Per 100 Sq. Ft.
4	1	6	14	.087	.025	.102	43
5	1	8	14	.062	.025	.077	34
6	1	10	14	.043	.025	.058	27
7	1	12	14	.026	.025	.041	21
23	1	¼″	12½	.147	.038	.170	72
26	1	6	12½	.087	.038	.110	50
27	1	8	12½	.062	.038	.085	41
28	1	10	12½	.043	.038	.066	34
29	1	12	12½	.026	.038	.049	28
31	2	4	12½	.238	.038	.261	106
32	2	5	12½	.202	.038	.225	92
38	3	4	12¼	.358	.038	.380	151
40	3	6	12½	.260	.038	.283	114
42	3	10	12½	.229	.038	.151	66

Length of Rolls: 150-ft., 200-ft. and 300-ft.

Widths: Approximately 18-in., 22-in., 26-in., 30-in., 34-in., 38-in., 42-in., 46-in., 50-in., 54-in. and 58-in.

Elastic limit of regular stock from 50,000 lbs. to 60,000 lbs. per sq. in., sectional area, 85,000 lbs. or over, ultimate strength.

Note—Material may be furnished either plain or galvanized. Unless otherwise specified, shipments will be made of material not galvanized.

the lighter bars can be simply lapped and wired.

Table 4 gives the properties of triangle mesh[11] reinforcing. The numbers here given are usually carried in stock and the 42-in. width is most commonly used.

Table 5 is useful for reference in calculating and ordering reinforcement.

Table 5

Diam. In.	Weight □ Bar 1′ Long	Weight ⊙ Bar 1′ Long	Area □ Bar Sq. In.	Area ⊙ Bar Sq. In.
¼	.212	.167	.0625	.0491
⅜	.478	.375	.1406	.1104
½	.850	.667	.2500	.1963
⅝	1.328	1.043	.3906	.3068
¾	1.913	1.502	.5625	.4418
⅞	2.603	2.044	.7656	.6013
1	3.400	2.670	1.0000	.7854
Gauge of Wire	**Diam. Ins.**	**Area Sq. In.**	**Lbs. Per Ft.**	**Ft. Per Lb.**
5	.207	.03365	.1135	8.81
6	.192	.02895	.0977	10.23
8	.162	.02061	.0696	14.36
9	.148	.01720	.0580	17.24
10	.135	.01431	.0483	20.70
12	.105	.00865	.0292	34.24

TANKS

The farmer of the present is fully alive to the value of the elevated water tank as a supply for his buildings and as a fire protection. Ordinarily the expense of a suitable tower and tank makes this water system so expensive as to be in many cases prohibitive. The concrete silo provides the solution as the expensive tower becomes a permanent fireproof silo paying large dividends to the owner.

Building the tank on top of the silo adds a small expense in comparison with the benefits received.

The tank must be carefully designed and built, the best of materials graded and used with special care. In very cold climates an outer wall or jacket should be provided for insulation or the tank sloped to resist ice, although owing to the constant change of water and variation of water level freezing is a less serious matter than is often supposed.

The exact procedure for construction of a silo tank is, like the construction of the silo, governed somewhat by the forms used and in most cases form manufacturers give specific directions for the use of their equipment.

In general the outer form is raised slightly and the inner form lowered or removed so that the floor form can be placed bearing either on the forms or supported by the staging. The floor joists must be very rigid to prevent any deflection. Forms should be designed for loads of 125 lbs. per sq. ft. in 16-ft. silos. See Fig. 12 and Table 6.

Table 6[12]

Dia. Silo, Ft.	A Ins.	B Ins.	C Ins.	D Ins.	E Ins.
8	9	1 x 4	2 x 4	2 x 4	2 x 8
10	10	1 x 4	2 x 4	2 x 4	2 x 8
12	11	1 x 6	2 x 6	2 x 4	2 x 10
14	12	1 x 6	2 x 6	2 x 4	2 x 10
16	Two 13	1 x 6	2 x 8	2 x 6	2 x 12
18	Two 14	1 x 8	2 x 8	2 x 6	2 x 12
20	Two 15	1 x 8	2 x 10	2 x 8	2 x 14

Sometimes the floor is made convex, which makes a stronger floor for the same amount of material, but complicates the form work. It is possible to give the crown by laying a level floor and covering with a low mound of dampened sand supported by boxes and carefully packed and swept to shape. The flat floor is more generally used.

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[11] Am. Steel & Wire Co., Chicago

[12] Courtesy Conklin Const. Co., Hartford, Mich.

The reinforcement to be used for tank floors is shown in Table 7 and its position in Fig. 13. The floor reinforcement should extend out into the walls and part of them should be bent up as shown in Fig. 12.

The reinforcing should be placed and well wired and supported about one inch from the forms by concrete cubes or metal chairs. The mix for the floor and tank walls in general should be about 1:2½:4 and the addition of 10% of hydrated lime to the cement will be valuable in securing density and as a waterproofing.

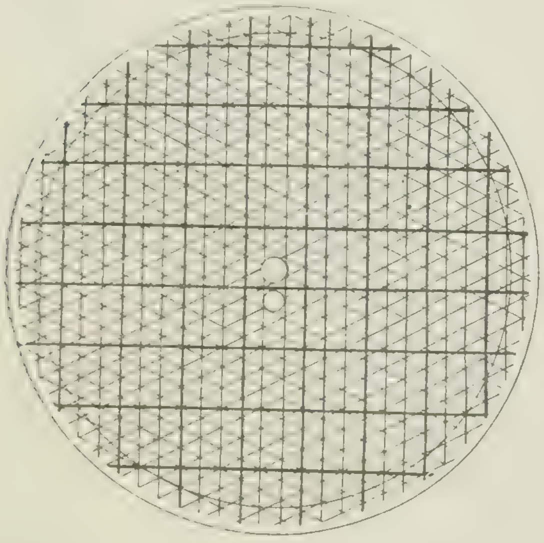


Fig. 13—Reinforcing Diagram for Tank Floor

The floor should be poured without stop and as rapidly as possible. Have the concrete "quaky" and compact it very thoroughly.

When the floor has partly hardened cover with a layer of damp sand to protect it and keep it from drying out, and set the forms for the walls. The joint between floors and walls must be roughened and thoroughly wet and brushed with neat cement paste just before pouring the walls.

WATER CONNECTIONS

Proper provision must be made for supply and overflow pipes.

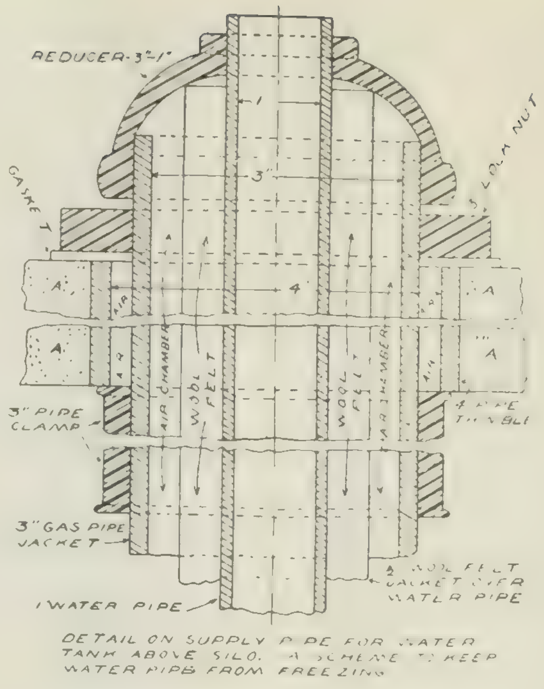
Figs. 14 and 15 give details of a frost protected installation.[12] See also Fig. 12.

The supply pipe can either be taken down straight through the silo or carried out into the chute; both methods have been successfully used.

Where carried into the chute start the piping at the bottom and put fittings on inside pipe first; the jacket fittings can be put on over them readily.

CONCRETE ROOFS

Many silos are built without roofs and in some localities that custom seems to give very satisfactory results. Most contractors are called on to roof their silos and while, as suggested by the previous article, less permanent materials can be used, the logical silo roof is of concrete.



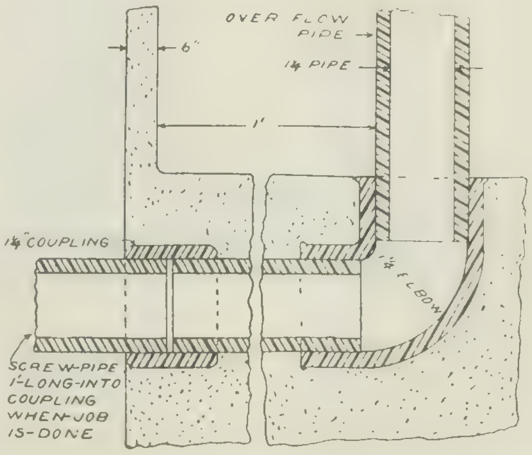


Fig. 14—Detail of Supply Pipe Connection with Frost Proof Casing

Fig. 15—Detail of Overflow Connection

Two methods of construction will be considered: 1, a form to be used when only one or two roofs are to be built and extra trouble for making removable forms would not be justified; 2, a collapsible form to be reused as often as desired.

Cornice.—The cornice form is the first consideration. The bottom forms can readily be cut out of plank as suggested in Fig. 16 and arranged to be fastened together in place. The method of support for the cornice forms depends upon the form used. Some are arranged for the attachment of brackets for the purpose of supporting the cornice. More often, however, it will be desirable to remove the silo forms and be independent of them in building the roof.

A convenient method is to leave holes in the silo walls about 30″ below the top by putting oiled pins or metal or card board tubes in the forms. Through these holes bolt ordinary carpenter's brackets to the wall to supply staging. At a point about 6″ below the top of the wall leave other holes at points determined by the size of the cornice sections.

An L-shaped iron bracket provides

(Continued on p. 82)

Table 7—Reinforcement for Concrete Tanks[12]

Diam. of Tank	Depth in Feet	Thickness of Bottom	Size of Steel Bars	Distance Apart	Size of Mesh in Bottom	Size	Bars Only in Wall Distance Apart	Size Wire Mesh Only in Walls 42″ Widths
8′	6′	9″	½″	20″	5	½″	10″	1 width of No. 5 1 " " " 4
8′	12′	9″	½″	18″	5	½″	10″	1 " " " 5 2 " " " 4–31 1 " " " 23
8′	18′	10″	½″	16″	5	½″	8″	2 " " " 5–31 2 " " " 4–31 2 " " " 23
10′	6′	10″	½″	18″	5	½″	10″	1 " " " 5 1 " " " 4
10′	12′	10″	½″	16″	5	½″	8″	1 " " " 5 2 " " " 4–31 1 " " " 23
10′	18′	11″	½″	14″	5	⅝″	8″	2 " " " 5–31 2 " " " 4–31 2 " " " 23
12′	6′	11″	½″	16″	5	½″	10″	1 " " " 5 1 " " " 4
12′	12′	11″	½″	14″	5	⅝″	8″	1 " " " 5 2 " " " 4–31 1 " " " 23
12′	18′	12″	½″	12″	5	⅝″	8″	2 " " " 5–31 2 " " " 4–38 2 " " " 23–38
14′	6′	12″	½″	16″	5	½″	10″	1 " " " 5 1 " " " 4
14′	12′	12″	½″	14″	5	⅝″	8″	1 " " " 5 2 " " " 4–31 1 " " " 23
14′	18′	13″	⅝″	12″	4′	⅝″	8″	2 " " " 5–31 2 " " " 4–38 2 " " " 23–38
16′	6′	13″	⅝″	14″	4	½″	10″	1 " " " 5 1 " " " 4
16	12′	13″	⅝″	12″	4	⅝″	8″	1 " " " 5 2 " " " 4–38 1 " " " 23
16′	18′	14″	⅝″	10″	23	⅝″	8″	2 " " " 5–31 2 " " " 4–38 2 " " " 23–38
18′	6′	14″	⅝″	12″	4	½″	10″	1 " " " 25 1 " " " 4
18′	12′	14″	⅝″	10″	23	⅝″	8″	1 " " " 31 2 " " " 4 1 " " " 23
18′	18′	15″	⅝″	8″	23	⅝″	8″	2 " " " 5–31 2 " " " 4–38 2 " " " 23–38

Design Methods in Concrete Construction—Retaining Walls

By S. M. Cotten[1]

This is the sixth of the series of articles on Design Methods in Concrete Construction, the first five being written by Jerome Cochran, C. E. In the first and the second article, published in Concrete-Cement Age *for Jan., 1915, and Feb., 1915, were given analytically and graphically, the general principles which govern the determination of the bending moments and shears in simple beams under applied loads. The analysis of stresses in reinforced concrete rectangular beams was considered in the third article, published in Mar., 1915, while the formulas used in designing T beams were considered in the April, 1915, issue, as well as the application of formulas to the design of beams and slabs. The design of columns and footings was treated in the fifth article, published in June, 1915.*

GENERAL CONSIDERATIONS

The principal factors in the design of a retaining wall of any type, are the earth thrust due to the backfilling and the allowable foundation pressure.

There have been advanced, and are in common use, a number of theories and formulas for the determination of the magnitude and direction of the earth thrust, but no one of these may be said to be authoritative. Each has its adherents, and the choice is largely one of individual preference or judgment. Those in most common use are probably Moseley's and Rankine's, an exposition of which can be found in a great many engineering works. The application of these theories to a given problem often gives results so widely divergent that a wall which would be amply stable under one assumption would be in imminent danger of failure under the other. Moseley's theory, which gives smaller results than Rankine's, is, in the opinion of the writer, the most reasonable and logical of any, and while it is certain that the assumptions therein are not absolutely true, they probably approximate the truth at least as closely as do any others.

It is not the purpose of this article, however, to discuss the question of earth pressures, or the merits of the various theories advanced for their determination. In the present state of our knowledge upon this subject, when it is generally conceded that the best of such theories are a mere guess at the truth, usually, and fortunately, leaning toward safety, the most sensible procedure, in the writer's opinion, is to use the comparative method of design. In this, the actual earth pressures are only indirectly considered, being indirectly reduced to an equivalent fluid pressure.

ADVANTAGES OF THE METHOD, AND WORKING HYPOTHESES

The advantages of this method are several. The first is founded upon a purely empirical mode of reasoning, which is, that while we may not know what actual earth pressures are acting upon a wall, we do fairly well know from actual experience, since translated into rules of good practice, what should be the minimum dimensions of a solid masonry wall to withstand successfully those pressures. That is, it is a generally accepted rule that a retaining wall of good masonry, top width of say 18″, with a battered or stepped back, with a base of from 0.4 to 0.5 its height, and with a substantial foundation, will be stable against all usual conditions of loading. Also, this ratio of base to height will most probably determine the acceptability of the design, regardless of any results derived from theoretical pressures. Again, while theoretically each particular wall should be independently designed, the lack of exact data and the uncertainty of the applicable theories in themselves invalidate such argument, though, of course, there is left a field for the judgment of the designer when conditions depart widely from the usual. In general, it is the custom in practice to assume "standard" conditions applicable to all walls, these assumptions being based upon the judgment of the designer. The only practical distinction which is made is between those in which the backfilling is level with the top of the wall, and those in which it is surcharged, or sloping upward from the top, this slope being usually assumed as $1\frac{1}{2}:1$.

Bearing in mind the state of our knowledge of earth pressures, it is the opinion of the writer that these distinctions are all that are usually waranted, so far as earth thrusts are concerned. But there is another and important factor which may materially modify the design, and that is the allowable foundation pressure. It has been said that practically all retaining wall failures have been foundation failures, i. e., an overloaded foundation. There is probably much truth in this observation, and it should be remembered that even though the actual earth pressures may be accurately determined and the wall properly designed with respect to these, it may still fail, because of an improperly designed foundation. Other things being equal and corectly designed, the stability of the wall with respect to the foundation will depend solely upon the width of the base, and this should be so proportioned as the bearing power of the soil may indicate. The minimum width will be determined by the earth thrust, while that required may be determined by the character of the foundation.

To return to the advantages of the comparative method, not the least of these is the relative ease of determination of pressures and design, once an equivalent fluid pressure has been decided upon.

THE DETERMINATION OF EQUIVALENT FLUID PRESSURES

The determination of equivalent fluid pressures is as follows:

In Fig. 1 are shown two usual and standard types of solid masonry, gravity walls. The masonry is assumed to weigh 150 lbs. per cu. ft. and the backfilling 100 lbs. per cu. ft. The actual earth pressures tending to overturn the wall about its toe will be replaced with an equivalent fluid pressure, P. This will be a horizontal force acting at $\frac{1}{3}h$ above the base, it being remembered that the resultant horizontal pressure of a fluid is applied at this point and is equal to $\frac{1}{2}ph^2$, where $p =$ the unit weight of the fluid.

Form (a) It is evident that the force P tends to overturn the wall about its toe, and that the forces W_1 and W_2, the latter being the weight of the backfilling resting upon the stepped back of the wal, tend to prevent this rotation, or to turn it in the opposite direction about the same point. Hence, it is required to determine that value of P, and consequently of p, such that the overturning moment of P will equal the resisting moment of W_1 and W_2, and afford at the same time an adequate factor of safety.

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[1] Engrg. Dept., Ray Consolidated Copper Co., Hayden, Ariz.

Form (*b*) The requirement is the same, but is much simplified by the absence of the force W_2 and the simplicity of outline of the wall.

If moments are taken about the toe of the wall, and a condition of equilibrium established because of the identical values of the overturning and the resisting moment, the wall would theoretically be just upon the point of failure. Since it is always customary to introduce a "factor of safety" into all design, which in the case of retaining walls should not be less than about 2, it is necessary that the origin of moments be taken at some point, considerably back from the toe. Also, because of the nature of foundation pressures under an eccentric loading, it is required that the resultant of the forces acting upon the foundation shall not pass outside the edge of the middle third. If it does do so, there is a portion of the foundation which is in tension, a condition which should not prevail in masonry construction. Also, since the entire resultant must be borne by the foundation, when the area of distribution is lessened the pressures under the toe might reach dangerously high values.

The distribution of foundation pressures is given by the following:

With reference to Fig. 2, let *A B* represent the foundation of a structure of width *l*, in feet. It is trisected at *t* and t_1, and bisected at *C*. Let *V* be the vertical component of the total force acting upon *A B*, and intersecting the same at *e*. The distance *e C* is denoted by *d*.

The greatest intensity of pressure will be developed at that end of *A B* on which side of the center *V* lies, in this case at *A*. Let p_1 equal the maximum intensity of pressure per sq. ft., and p_2 the minimum. Then, it may be shown by advanced mathematics that

$$p_1 = \frac{V}{l} + \frac{6Vd}{l^2} \qquad (1)$$

and

$$p_2 = \frac{V}{l} - \frac{6Vd}{l^2} \qquad (2)$$

The intensity varies uniformly between these points. The value of p_2 may be either plus or minus; the latter if the resultant intersects the foundation plane outside the edge of the middle third. Obviously,

$$\frac{(p_1 + p_2)\,l}{2} = V$$

If the resultant intersects at the edge of the middle third, then $d = \frac{l}{6}$, and we have:

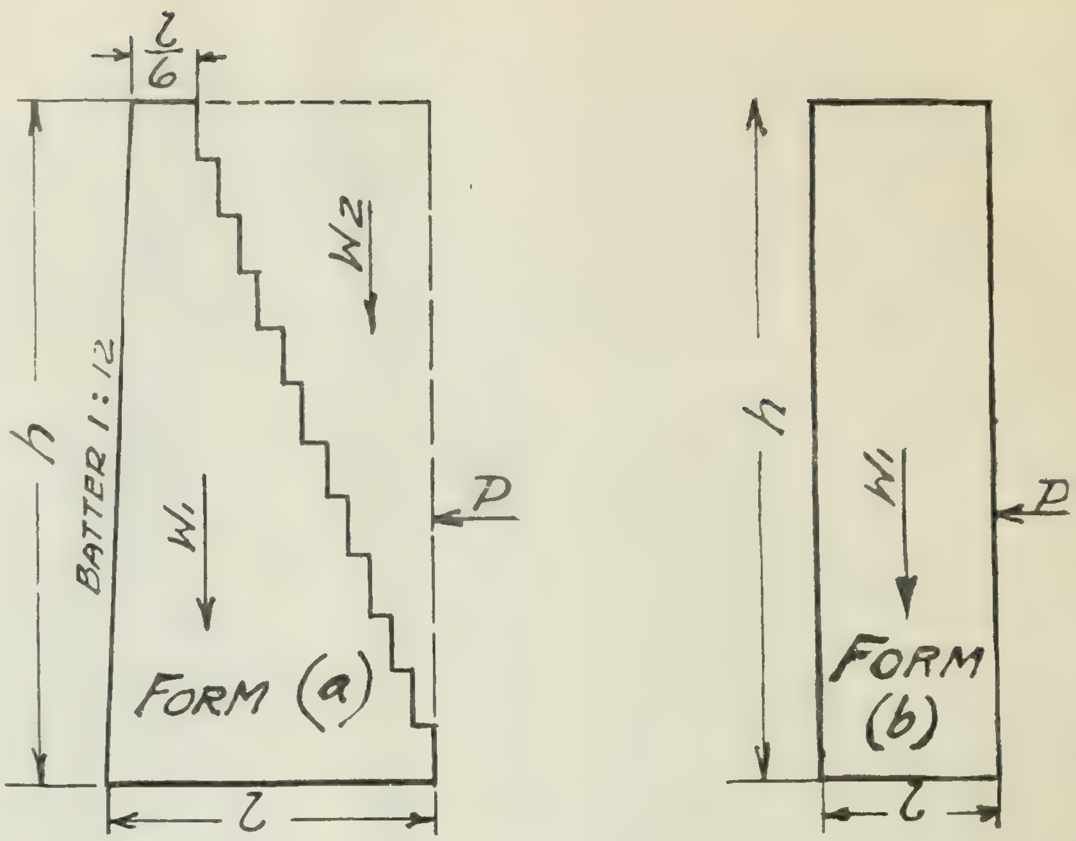


Fig. 1—Standard Types of Solid Masonry, Gravity Retaining Walls

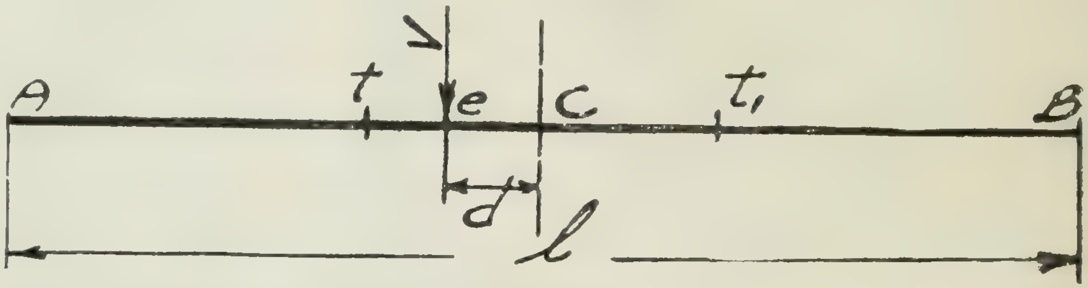


Fig. 2—Distribution of Foundation Pressures

$$p_2 = \frac{V}{l} - \frac{6Vd}{l^2} = \frac{V}{l} - \frac{(6V)\frac{l}{6}}{l^2}$$

$$= \frac{V}{l} - \frac{6Vl}{6l^2} = \frac{V}{l} - \frac{V}{l} = 0$$

That is, the pressure will be represented by a right-angled triangle, a maximum at p_1 and decreasing uniformly to *0* at p_2.

By taking moments about the edge of the middle third, all conditions are satisfied, and, as will be shown later, it is the best possible point about which they can be taken. It should be borne in mind that when a condition of equilibrium prevails, the resultant will pass through the origin of moments.

Referring again to Fig. 1, *Form* (*a*). As is customary, a length of wall of 1′ will be considered. The process is too laborious, and would require too much space to be worked out here, but if W_1 represent the weight of masonry per lin. ft. of wall, W_2 the weight of the earth filling resting upon the back of the wall, and if the position of these forces be determined and moments taken about the edge of the middle third and equated to the equivalent fluid pressure *P*, the value of which is *1/2 ph*² and the arm of which is *1/3 h*, there will be derived the relation

$$p = 132\,\frac{l^2}{h^2} \qquad (3)$$

Referring to *Form* (*b*), the process is much simplified, because of the form of wall. The only forces to be considered are the weight W_1 and the pressure *P*. Equating as before, we have,

$$(150hl)\,\frac{l}{6} = \frac{1}{2}\,ph^2\,\frac{h}{3} =$$

$$ph^2\,\frac{h}{6} = \frac{ph^3}{6}$$

$$\frac{150hl^2}{6} = \frac{ph^3}{6},\ 150hl^2 = ph^3,$$

$$p = \frac{150hl^2}{h^3} = 150\,\frac{l^2}{h^2} \qquad (4)$$

A considerable change in the top width of *Form (a)* has a scarcely appreciable effect upon the coefficient. If the former be made *0*, the latter would only change to 127. It is evident also that within the limits of practice, the amount of face batter would not appreciably effect the coefficient.

Substituting in equations (3) and (4), various values of l/h, we derive the following values of p, or equivalent fluid weight under which the wall would be stable under the assumptions stated:

Form (a)

l/h	p
⅓	14.7 lbs. per cu. ft.
4/10	21.1 lbs. per cu. ft.
½	33.0 lbs. per cu. ft.

Form (b)

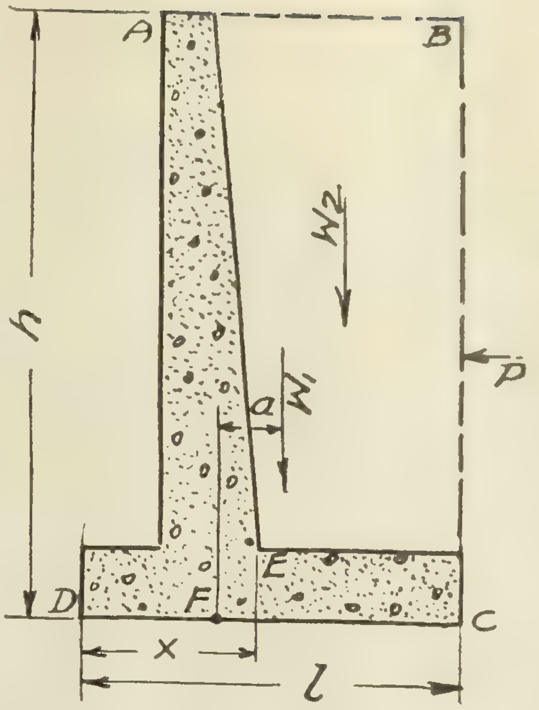
l/h	p
¼	9.4 lbs. per cu. ft.
⅓	16.7 lbs. per cu. ft.
4/10	24.0 lbs. per cu. ft.

Trautwine, in his *Civil Engineer's Pocketbook*, gives a ratio of base to height of 0.4 for a good masonry wall of *Form (b)*, where there is no surcharge. This ratio may be said to represent good practice, and is probably the most usual criterion of design. It is to be noted that the equivalent fluid weight under which such a wall would be stable as before assumed, is 24 lbs. per cu. ft.

The average ratio of base to height of the standard retaining walls of *Form (a)*, of five of the largest railroad systems in the country, is 0.48, giving an equivalent fluid weight of approximately 33 lbs. per cu. ft.

It should be noted that the conditions imposed upon walls in such service are probably the most severe possible. They have to carry not only an earth surcharge, but also a further equivalent one in the form of moving train loads, and the vibration due to these greatly increases their nominal magnitude. A very slight continued vibration in a retaining wall might easily result in failure, though the structure be capable of resisting many times the existing earth thrusts. It is worthy of mention, in this connection, that, so far as the writer can learn, retaining wall failures have almost without exception been gradual and have taken place after quite a considerable period of service, whereas if earth thrust alone be considered, the failure, if occurring at all, should take place at the time the backfilling is put in, since this is then less compacted than at any subsequent time and hence gives the greatest thrust.

Upon the basis of these investigations it appears that good practice would indicate that for the basis of design there be adopted for the minimum, applicable to unsurcharged walls, a fluid weight of 20 lbs. per cu. ft., and for the maximum, applicable to surcharged railway embankments, 33 lbs. per cu. ft. A value of 27 lbs. per cu. ft. should be ample for all usual surcharged conditions where the fill does not carry a railroad or other extremely heavy triffic.



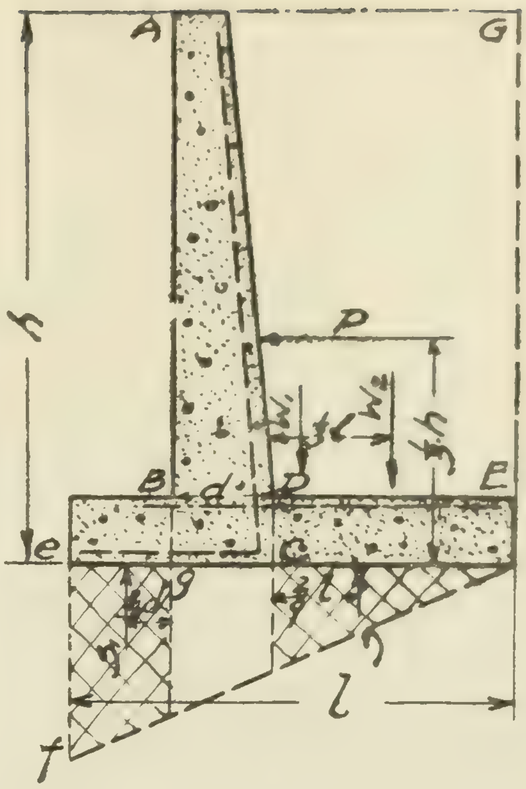


Fig. 3—Cantilever Type of Reinforced Concrete Retaining Wall

Fig. 4—Forces Acting Upon the Wall

WIDTH OF BASE AND RELATIVE STABILITY OF REINFORCED CONCRETE WALLS

In Fig. 3 are given the essential outlines of the usual type of reinforced concrete wall, known as the cantilever; also the forces acting upon it, excepting the foundation pressures, which need not now be considered. It consists of a vertical wall attached to a floor, or footing. There is a reciprocal cantilever action between the vertical wall and the floor sections in front and in rear. This form of wall is conceded to be the most economical up to heights of about 18′, under ordinary conditions of pressure. There is another common form of reinforced concrete wall, a variation of the simple cantilever type, known as the buttressed wall, which is used for greater heights. This will be discussed later. In either case, the earth pressures act in the same manner, and the necessary width of base is found by the same methods.

Let l= width of base

x = distance from toe to back of wall $A\ E$

h = height

p = equivalent fluid weight

w_2 = wt. of earth filling per cu. ft.

W_1 = wt. of masonry per lin. ft.

W_2 = wt. of earth above the floor $E\ C$, per lin. ft.

a = lever arm of W_1 about the edge of the middle third, F

P = total fluid pressure $=1/2ph^2$

Equating moments about the point F, we have,

$$W_1a + W_2 \quad \frac{2}{3}l \quad \frac{l-x}{2} = \frac{Ph}{3}$$

or

$$W_1a \quad w_2h \quad l-x \quad \frac{2}{3}l - \frac{l-x}{2}$$
$$= \frac{ph^3}{6}$$

If $A\ E$ is placed well toward the front, the moment of the masonry will be negligible. Dropping the term W_1a and putting $x = kl$, we get

$l = h$ into the square root of

$$\frac{w_2\ (1 + 2k - 3k^2)}{p} \qquad (5)$$

Investigation will show the value of l to be a minimum when $k = 1/3$; that is, when $x = 1/3\ l$. With this value of k, equation (5) becomes:

$l = .87$ into the square root of

$$\frac{p}{w_2}.h \qquad (6)$$

For w_2 100, as is generally assumed,

$l = .087$ into the square root of

$$p\ .h \qquad (7)$$

which represents the most economical width of base.

If, for example, the value of p be taken at 33 lbs. per cu. ft., corresponding to a value of $l/h = 1/2$ for a solid wall of Form (a), then $l = .087$ into the square root of $33\ .h = 0.5h$. This shows that the stability of the reinforced concrete wall is practically the same as that of a solid wall of *Form (a)* having the same value of l/h. If p be taken as 24 lbs. per cu. ft., corresponding to a value of $l/h = 4/10$ for a solid wall of *Form (b)*, we have $l = .087$ into the square root of $24\ .h = 42.7\ h$, showing that the stability of the reinforced wall is not quite

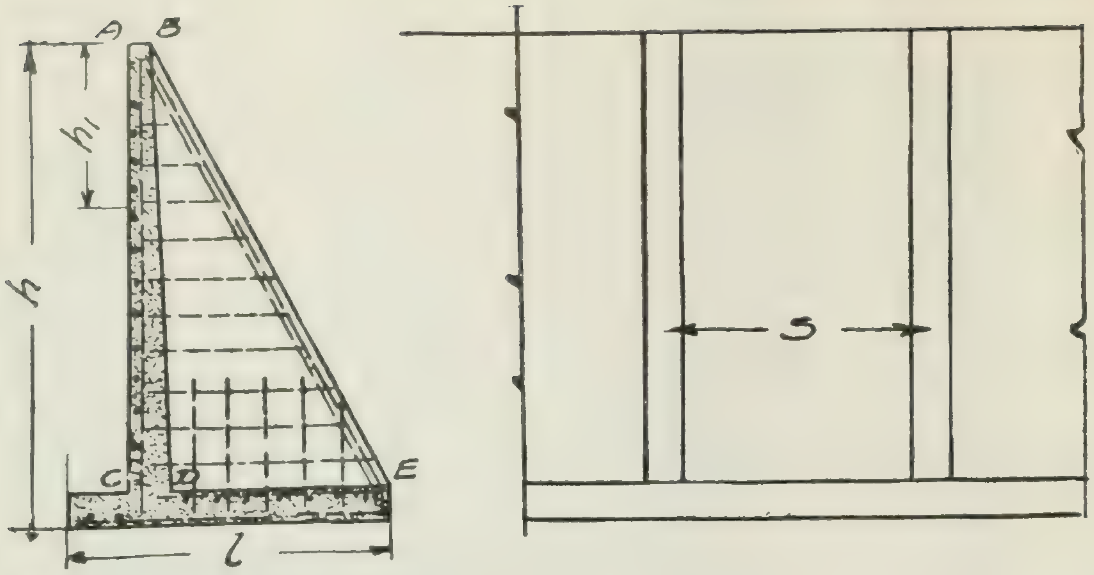


Fig. 5—Buttressed Type of Cantilever Retaining Wall

so great as that of a solid wall of *Form (b)* having the same proportional base.

A considerable change in the value of x results in a scarcely appreciable change in the value of l/h. Should x be made either very large or very small, however, the weight of the wall W_1 should then be taken into account, the term W_1a, dropped from equation *(5)*, becoming then too large to be disregarded. The value of l/h increases, both as x increases and decreases from $1/3\,l$. Cases in which it is desirable or necessary to depart from this value will, of course, be very rare.

FORCES ACTING UPON THE WALL

In Fig. 4 are shown the wall and all the forces acting upon it. These consist of the weight of the wall itselw W_1, the weight of the earth vertically above, and resting upon the rear footing, the equivalent fluid pressure P, and the foundation pressures S and S_1. It is assumed that the resultant passes through the edge of the middle third, and that $x = 1/3\,l$.

The total foundation pressure $= W_1 + W_2$, and is distributed as per formulas *(1)* and *(2)*. In this case, the foundation pressure diagram is a triangle, as shown, the maximum pressure being equal to $2\dfrac{W_1 + W_2}{l}$, and represented by the line $e\,f$. The pressure at any other point on the base will be represented by the intercept on a vertical line joining the point and the hypothenuse of the triangle. Only the shaded portions of the foundation pressure diagram are considered, since that part immediately under the vertical wall has no effect upon the design S_1 and S_2 are the resultants of the pressures indicated by the shaded areas, and pass through their c. g's.

DESIGN OF WALL

It is apparent from Fig. 4 that the force P tends to turn the vertical wall about the point B; the force S_1 to turn the front footing about the point g; the force W_2 (since W_2, in any properly designed wall, is always far greater than S) to turn the rear footing about the point D. All the members constituting the wall act as cantilevers.

The maximum bending moment in the vertical wall, at BD, $= P\left(\dfrac{h}{3}\right) = 1/2\,ph^2\left(\dfrac{h}{3}\right) = \dfrac{ph^3}{6}$

That in the front footing, at Bg, $= S_1\left(\dfrac{1/3\,l - d}{2}\right)$, since for all practical purposes S_1 may be considered to bisect the line eg.

That in the rear footing, at $D\,C$, $= W_2\left(\dfrac{l}{3}\right) - S\left(\dfrac{2\,l}{9}\right)$.

If, for any reason, the wall is so proportioned that the resultant does not pass through the edge of the middle third (it should never pass outside of this) the foundation pressures will, of course, no longer be represented by Fig. 4, nor will the moment arms of the various forces except P, be as given there. The magnitude and position of these forces for any condition should be readily found from the foregoing explanations and formulas.

Having found the maximum moments existing in the various members, it is only necessary to place here a reinforced concrete beam 1′ wide, giving a resisting moment of the same magnitude. This thickness will be required only at the sections of maximum moments, $B\,D$, Dc, and Bg. The moments in the vertical wall vary as the cubes of the distance from the top, hence a wall tapering uniformly from zero at the top would give a beam the weakest point of which would be at the bottom. The moments in the footings vary as the square—plus of the distance from the fixed end. Hence a beam of zero thickness at the free end and tapering uniformly to the fixed end would be theoretically sufficient. For practical reasons, however, the least thickness of beam at the free end should not be less than from 6″ to 8″.

For the same reasons as above, the amount of steel required at the sections of maximum moment need not be carried throughout the beam. For the vertical wall not more than every third rod need be carried to the top, each of the other two being carried only to such a height as required by the moments. The same argument is also applicable to the footings, but the rods in these are usually so short in any case that it is not worth while to try to decrease their length. The necessity for bond would probably make such an attempt impracticable, it being remembered that a rod must have requisite bond on both ends. That is, a rod not otherwise secured must be carried a length necessary for bond beyond that section at which it is required by the moment

If the front footing be made of the same thickness as the rear, and the rods from the vertical wall be bent so as to form its reinforcement, as shown in Fig. 4, no attention need be paid to it with respect to bending and resisting moments, but it should be investigated for bond and shear. Shear in the vertical wall and the rear footing is always sufficiently cared for by the thickness required for moment.

Great care should be taken to have sufficient bond length for all rods. This is sometimes difficult to accomplish, and the custom of hooking the end of the rods has often been resorted to. Extended experiments by the Univ. of Ill. have led to the conclusion that the hooked end possesses little or no bonding value. Hence it would be well, where at all possible, to avoid this practice.

For distribution of load and temperature, longitudinal reinforcement, about 4% for very thin walls to 2% for heavy walls, should be placed. It is the custom in practice to use for this purpose ⅜-in. or ½-in. rods 12″ o. c.

It is quite usual practice to put in a fillet of about 18″, at the junction of the vertical wall with the rear footing, and in this a short additional rod. As an added factor of safety there is no fault to be found with this custom, but, theoretically, at least, it is not at all necessary.

If, for any design, the foundation pressures under the toe should exceed the bearing power of the soil, simply lengthen the front footing as required to reduce the pressures to the proper figure. No other dimensions need be changed. This will increase S and decrease S_1, in the same amount, approximately, the foundation pressure diagram becoming a trapezoid. There is of course, a limit to this procedure, but it is not likely to be reached if the soil is of a kind upon which any sort of structure could be placed without piling.

THE BUTTRESSED TYPE

The buttressed wall, Fig. 5, consists of the simple cantilever type with the addition of the wall *B D E* at intervals. While the forces act in identically the same manner as in the cantilever type, and while all the determinations relative to this are applicable to the buttressed wall, the members composing this latter act, and are designed, in an entirely different manner.

The wall *B D E* acts as a cantilever, fixed to the rear footing. If s = the interval, in feet, between these walls, then $S\ (1/2\ ph^2)$ is the bending moment at each wall, or beam.

The vertical wall *A B C D* is designed as a slab, supported at the beams *A D E*, the loading at any point being in accordance with the equivalent pressure at the same. That is, at any point h' from the top, the load per ft. width of slab = $S\ (1/2\ ph'^2)$. This beam is continuous over the supports, and the reinforcement must be placed accordingly. The rear footing is also designed as a slab, supported at the same points, and continuous over supports. The load at any point is equal to the difference between the earth load pressure from above and the foundation pressure from below. It is not possible, nor desirable, of course, to design these slabs in exact accordance with the moments at every section. These latter, or the loadings, must be averaged as indicated by the judgment of the designer. The front footing is designed in the same manner as for the simple cantilever type. The distributing and the temperature reinforcement are the same as for that type.

It is quite essential that the various members of this wall be thoroughly bonded together, and for this purpose it is necessary that the reinforcing steel in each member be carried well into every adjoining member, where this is at all possible. The support of the vertical wall slab and the rear footing slab, being a pull, not a push, is one of the weak points of this type, and can be overcome only by the proper use of steel. Both the vertical and the horizontal rods in the cantilever beam *B D E* are placed there primarily for this purpose, and that this may be accomplished it is necessary that these rods have a bent end of 90° entering well into the slabs. It will be remembered that concrete is never designed to withstand tension. This must be carried entirely by steel placed for that purpose, and sufficient bond length allowed.

The entire moment in the cantilever is considered to be resisted by the inclined rods near the outer side. In order that these rods may have sufficient bond it is necessary to bend their lower ends and carry them well into the rear footing.

The spacing of the cantilever beams *B D E*, is, in general, a matter to be determined only by the relative economy of different designs, and the best spacing can be determined by trial only. There is, of course, for every height and pressure, one spacing which will give a more economical wall than will any other. The maximum spacing for economy, in any case, will not likely exceed 8′, this being probably somewhat above the limiting economical span for slabs.

GENERAL REMARKS

All retaining walls, regardless of type, should have drain pipes, or holes, through them, so that no water can collect on the near side and result in a full hydrostatic head. Even the thinnest film of water behind a wall would result in an actual fluid weight of 62.4 lbs. per cu. ft., instead of the assumed equivalent one of from 20 lbs. to 33 lbs. A layer of gravel, crushed stone, or other porous material, about 12″ to 18″ thick should be placed next the back of the wall.

The base of the footing should not be less than 3′ below the ground line, unless placed upon solid rock. This should ordinarily constitute a sufficient protection for the foundation, and remove all chance of the wall sliding upon its base. If there is any doubt as to this latter, however, an additional safeguard may be had in a projection 12″ or 18″ below the base, and preferably being a continuation of the lines of the vertical wall.

ACKNOWLEDGEMENT

The writer acknowledges his very great indebtedness to Turneaure and Maurer, *Principles of Reinforced Concrete Construction,* for much of material herein; since, in some cases, the form of their discussion was the very best possible for the needs of this article, and could not be altered or departed from without injury to this discussion, theirs has been adopted almost verbatim.

New Records in Mixing and Placing Concrete

Further records for the mixing and placing of concrete with ½-yd. mixers on the Panama Canal were made by the forces of the Division of Terminal Construction on the south wall of dry dock No. 1 at Balboa April 10. Of the performance the *Canal Record* says:

> The regular mixer battery on the south wall consists of four half-yard mixers, working in units of two. One of the mixers in one of the units was closed down and the two crews of the unit fed the other mixer. In the 8-hr. day, the double-crew mixer mixed approximately 321.94 cu. yds. of concrete, as calculated on this basis: The total place measurement of the output of the three mixers was 655 cu. yds., mixed in 1,005 batches. Each batch averaged, accordingly, .6517 cu. yds. Of the 1,005 batches, the double-crew mixer mixed 494, which, on the basis of the average for all batches, may be taken to mean 321.94 cu. yds.
>
> The time charged to this mixer was as follows:
>
> | | Hours | Cost |
> |---|---|---|
> | 1 foreman | 4 | $ 2.71 |
> | 1 sub-foreman | 8 | 2.00 |
> | 1 mixer runner | 8 | 1.04 |
> | 1 mixer helper | 8 | 1.04 |
> | 1 lever man | 8 | 1.04 |
> | 1 man cleaning runway | 8 | 1.04 |
> | 2 men carrying cement to hoppers | *8 | 2.08 |
> | 2 men wheeling cement | *8 | 2.08 |
> | 2 men in cement car | *8 | 2.08 |
> | 18 men handling wheelbarrows | *8 | 18.72 |
> | 1 helper on wheelbarrows | 8 | 1.04 |
> | Total labor cost | | $34.87 |
>
> *8 hours for each man
>
> In the 8-hr. period 30 min. were lost while the chutes for the mixed concrete were being washed, and 1 hr. and 15 min. were lost in waiting for forms. The actual working time was, accordingly, 6 hrs. and 15 min. The ½-yd. mixer, therefore, made a record of mixing 321.94 cu. yds. of concrete in 6 hrs. and 15 mins., at a cost of $34.87, or $.108 per cu. yd.
>
> The yardage of gravel used is about the same as the yardage of concrete mixed The 18 men trundling the wheelbarrows handled, therefore, in the 6 hrs. and 15 mins. about 321 cu. yds. of gravel, an average of 17.8 yds. per man. This is equivalent to 2.85 cu. yds., or about 76.9 cu. ft. per hour. As the gravel as handled at the dry dock weighs about 115 lbs. to the cu. ft., each man was handling about 8,840 lbs, or 440 tons, per hr. of working time, which is an average of over 147 lbs. per min.

Pure sand does not discolor water. If by way of test a sample is put in water, and the latter becomes cloudy, the sand must be "washed" before it is fit for use.

The Mechanical Grading of Concrete Sand

By George P. Dieckmann[1]

At the 10th annual convention of the Mid-West Cement Users Assn., held at Omaha, Nebr., Mar. 3-5, 1915, George P. Dieckmann[1] presented a paper illustrated with charts summarizing his experiments on the grading of concrete sands and the effect of grading as shown by tensile strength and absorption tests.

Mr. Dieckmann summarizes his tests as follows:

Series No. 1

All mortar 1:3. Sand used was screened through different sieves and a graded sand was thus obtained:

From 100-mesh—test A
From 50-mesh—test B
From 30-mesh—test C
From 20-mesh—test D
From 10-mesh—test F
From 4-mesh—test F

All mortar used consisted of 1 part cement and 3 parts Northwestern States Portland cement.

Average results are given on five briquettes for each test on tensile strength.

Average results are given, after 24 hrs. immersion on two dry briquettes for absorption.

All tests are made at 7 das. and 28 das.

Tensile Tests—The highest results are obtained on a sand passing a 10-mesh sieve at 7 and 28 das.

A mixture of 1 part cement and 6 parts of this sand would be stronger than a mixture of 1 part cement and 3 parts sand passing a 50-mesh sieve.

Absorption—The highest absorption is obtained on sand passing a 100-mesh sieve.

The lowest absorption is obtained on sand passing a 20-mesh sieve. See Fig. 1, A and B.

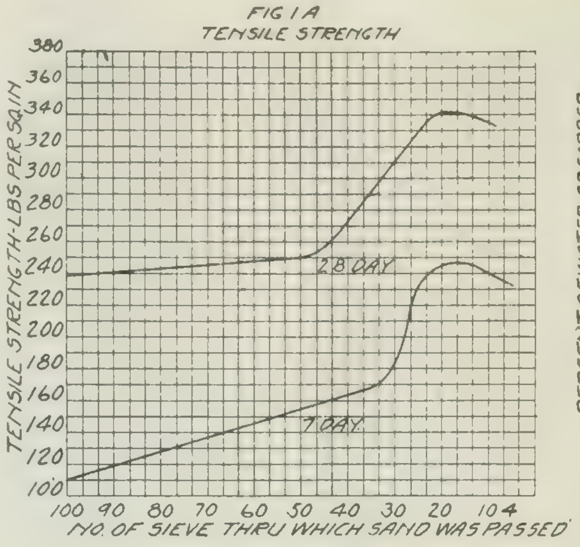


FIG 1A
TENSILE STRENGTH

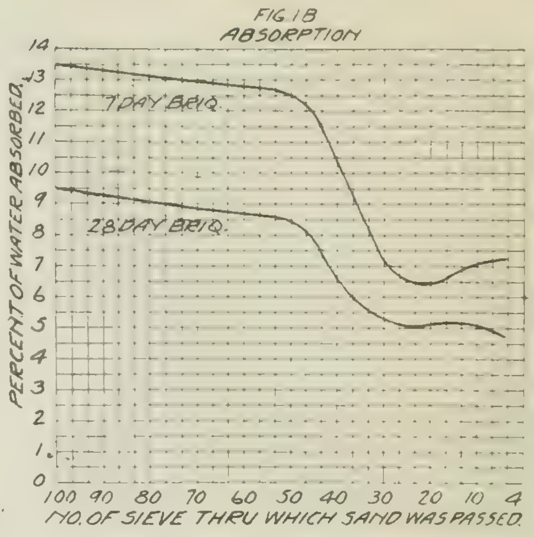


FIG 1B
ABSORPTION

Series No. 1

	A	B	C	D	E	F
Sand passing sieves	No. 100	No. 50	No. 30	No. 20	No. 10	No. 4
Tensile tests, 7 das.	110	155	168	229	234	225
Tensile tests, 28 das.	238	251	299	334	341	335
Absorption test, 7 das., 24 hrs. in water	13.5%	12.7%	7.2%	6.4%	6.9%	7.2%
Absorption test, 28 das., 24 hrs. in water	9.5%	8.6%	5.4%	5.4%	5.2%	4.7%

Series No. 2

	A	B	C	D	E	F
Percentage added	0%	10%	20%	30%	40%	50%
Tensile tests, 7 das.	222	192	220	165	182	145
Tensile tests, 28 das.	323	345	345	295	312	285
Absorption test, 28 das., 24 hrs. in water	5.6%	6.5%	6.6%	7.4%	7.1%	10%
Absorption test, 7 das., 24 hrs. in water	5.1%	5.5%	5.7%	5.4%	8%	9.4%

Series No. 3

	A	B	C	D	E	F
Percentage of sand passing a 50-mesh sieve	0%	10%	20%	30%	40%	50%
Tensile test, 7 das.	247	243	225	207	188	163
Tensile test, 28 das.	350	334	361	359	318	326
Absorption test, 7 das., 24 hrs. in water	9.9%	5.4%	6.1%	6.1%	7.1%	7.7%
Absorption test, 28 das., 24 hrs. in water	5.4%	6.4%	5.9%	5.5%	5.3%	5.1%

Series No. 2

Test A—Mortar 1:3. Sand used was retained on a No. 100 sieve. To tests B, C, D, E and F were added different percentages of sand passing a 100-mesh sieve to determine the influence of fine sand in the mortar.

Tensile Tests—The highest results are obtained on sand carrying from 0% to 20% fine sand on the 7 das. and 28 das. tests.

Absorption—With the increase of fine sand the absorption is raised at 7 das. and 28 das.

Comparing tensile and absorption tests, the sand carrying 10% fine sand has given the best results. See Fig. 2, A and B.

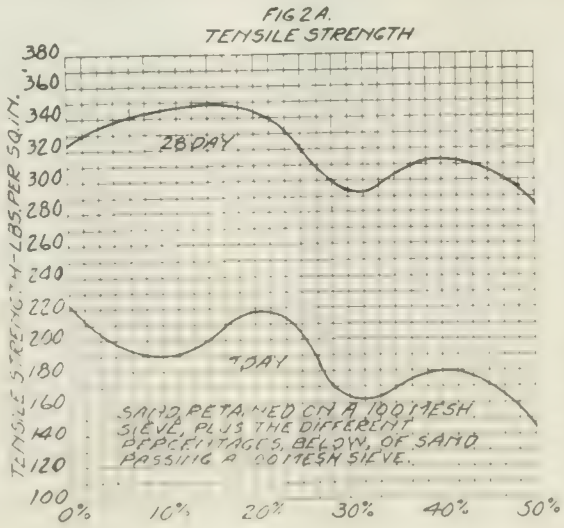


FIG 2A.
TENSILE STRENGTH

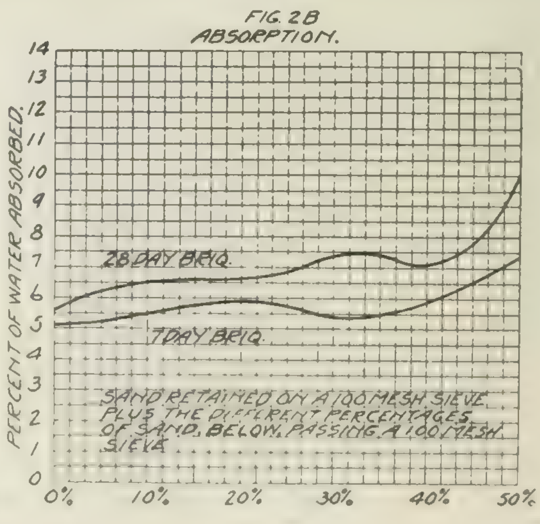


FIG. 2B
ABSORPTION.

Series No. 3

Test A—Mortar 1:3. Sand used was retained on a sieve No. 50. To tests B, C, D, E and F were added the different percentages of sand passing the 50-mesh sieve to determine the amount a concrete sand should carry passing and retained on a 50-mesh sieve.

Tensile Tests—The highest results are obtained on a sand having 20% and 30% sand passing a 50-mesh sieve, at 7 das. and 28 das.

Absorption—The highest absorption tests are obtained on the sand having more than 30% passing through a 50-mesh sieve.

Comparing tensile and absorption tests the sand having 20% to 30% through a 50-mesh sieve should give good results. See Fig. 3, A and B.

Series No. 4.

Test A—Mortar 1:3. Sand used was all passed through a No. 10 mesh sieve. To the tests B, C, D, E and F were added different percentages of sand which was retained on sieve No. 10 and passing sieve No. 10 to determine the amount of coarse sand which could be carried with best results in a concrete sand.

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[1] Chem., Northwestern States Portland Cement Co., Mason City, Ia.

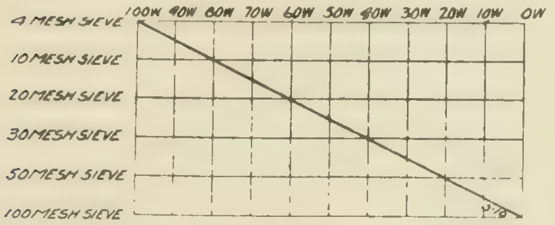


FIG. 5—STRAIGHT SAND LINE

SERIES NO. 4

	A	B	C	D	E	F
Percentage of sand retained on No. 10 mesh	0%	10%	20%	30%	40%	50%
Tensile test, 7 das	202	189	251	232	244	244
Tensile test, 28 das	318	338	357	344	335	340
Absorption test, 7 das., 24 hrs. in water	6.8%	5.2%	5.9%	6.3%	8.4%	5%
Absorption test, 28 das., 24 hrs. in water	5.7%	5%	4.7%	5.6%	5.3%	6.2%

FIG 3A
TENSILE STRENGTH

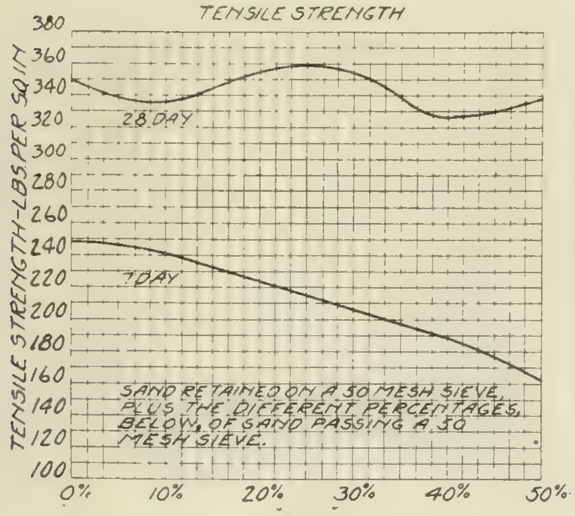


FIG. 3B
ABSORPTION.

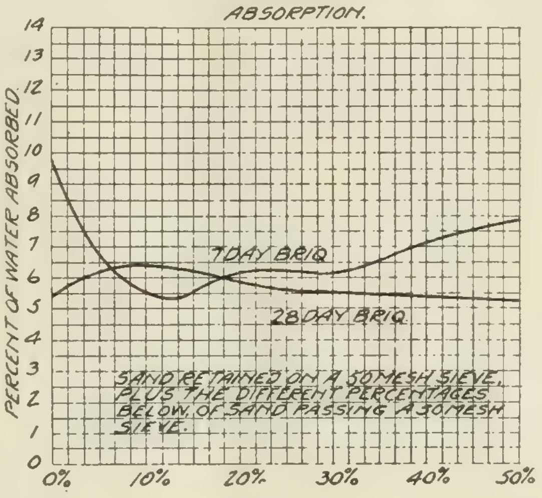


FIG 4A
TENSILE STRENGTH

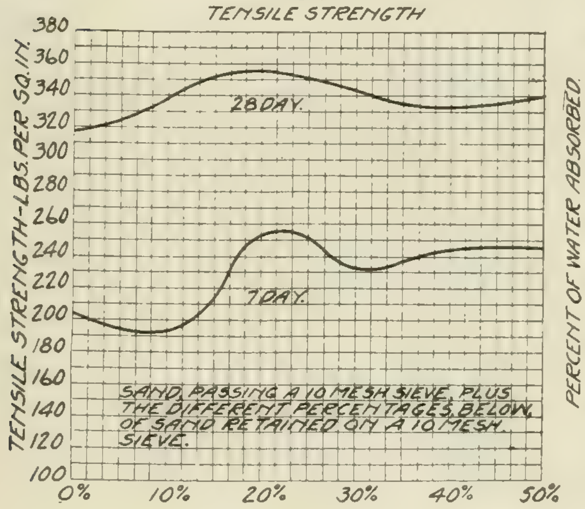
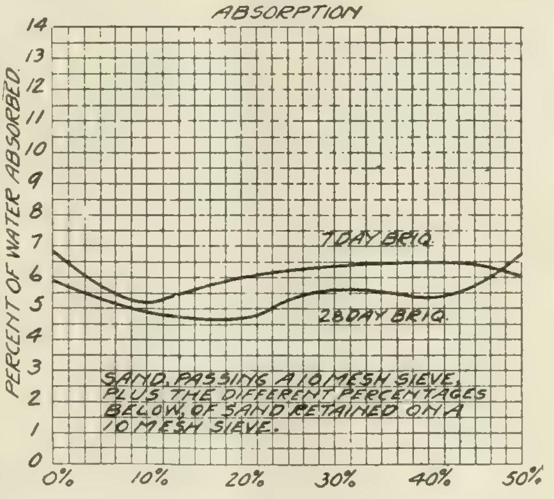


FIG. 4B.
ABSORPTION



Tensile Tests—The highest results are obtained in the sand having 20% and 30% through a 10-mesh sieve. See Fig. 4, A and B.

Considering all the tests, the following conclusions were reached: The best and most dense cement mortar for concrete is obtained if a sand has the following mechanical composition, as shown in Fig. 5 and called the straight line:

5% to 10%	passing	100-mesh sieve
20% to 30%	passing	50-mesh sieve
40%	passing	30-mesh sieve
60%	passing	20-mesh sieve
80%	passing	10-mesh sieve
100%	passing	4-mesh sieve

A Workman's Compensation law went into effect July 1 in the state of Vt.

A Method of Carrying Concrete Road Over Trenches With Soft Backfill

In constructing concrete pavement at Elizabeth, N. J., soft filling of old gas, sewer and water trenches in several places proved impossible to compact by roller to the solidity of the approach sub-grade. To excavate and refill would cost excessively and recourse was taken by the engineer, W. H. Hunter, Jr., to a method of bridging. He excavated the whole intersection 3″ in excess of the contract requirements, rammed broken stone in the trenches and when sufficiently dry applied 9″ of concrete over the whole surface thus prepared. By so doing the specifications were not exactly followed but the sub-grade was prepared in such a manner that the extra concrete would bridge the trenches in a satisfactory manner. To make repairs to the road when cut through for future trenches a somewhat similar construction is planned as follows: The concrete will be cut 6″ wider on each side than the excavated trench, and will be excavated 3″ below the sub-grade on the shoulder; the refill must be made as compact as possible. The old concrete must then be cut as a skew-back on each side so that the opening is 4′ wider at the top than at the bottom. Number 10 expanded metal or its equivalent of ½-in. steel bars is to be placed 2″ above the newly prepared sub-grade; the space is then to be filled with concrete while the sides of the old pavement are fresh cut and clean. After hardening a sufficient time, absolutely guarded against traffic, it is to be recoated with bitumen.

Expansion joints will be repaired with a suitable brand of hot paving pitch, being poured into the joint after it has been cleaned of loose foreign material, and the edges cleaned by chisel or other suitable tool, after which it will be filled with ½-in. gravel and then allowed to harden.—*Engineering and Contracting.*

Concrete Block Smoke House

The concrete block smoke house shown in the accompanying illustration is a home-made affair, the block produced from a home-made mold. Many farmers would rather buy the block and hire the work done. This particular smoke house was built by George Cobb, Elsie, Mich. He made the mold so that 16 block make a circle 5′ in diam. inside. The block are 4″ thick, walls are 8′ high and the roof is of concrete 2″ thick on metal fabric. The illustration also shows a poultry house, 16′ x 40′, the block made by Mr. Cobb on a Hobbs[1] machine.

CONCRETE BLOCK SMOKE HOUSE

The liberal margin of safety of some reinforced concrete was well illustrated during a building operation where some of the lower floors were finished and the material needed for the balance of the construction was stored on them. The engineer discovered to his horror that the weight of this material was ten times greater than the load capacity for which the floor had been designed. Nevertheless, the only thing that gave way to the strain was the temper of the engineer, who ordered the material removed.

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[1] Hobbs Concrete Mchy. Co., Detroit

Information and *Consultation*: The How-to-Do-It Department □ □ □

This magazine is for service. Let it serve you, and you help it to serve. You want special information. Ask us. We know the men who know.

Design of Reinforced Concrete Buildings □ □ □ □

Discussed By:
A. C. Janni[1]
A. M. Wolf[2]
L. R. Viterbo[3]

1. "Is it right to consider beams entering wall columns as continuous or partially continuous?

2. "Should the effect of eccentric loading on columns be considered?

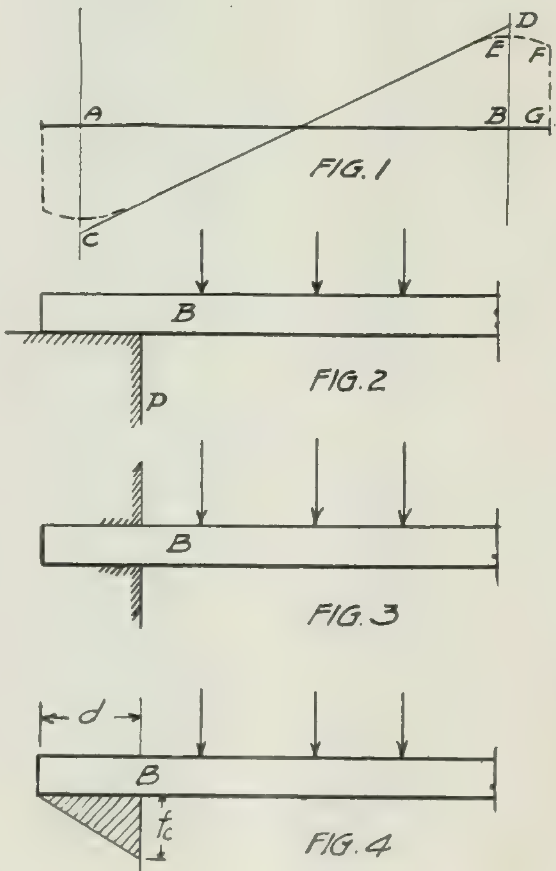
3. "If a beam enters a wall column and is considered to be continuous or partially continuous, what effect does it have upon the eccentric loading of the columns?

4. "If a column is avowedly eccentrically loaded and no provision for this is made in the design should we consider entering beams as freely supported or consider them as continuous or partially continuous because of the monolithic nature of the construction?"

By Mr. Janni

(1) In general, a beam entering a wall column, or any other quasi-rigid long support, may be considered as continuous, or partially continuous, according to the conditions of the supported end of the beam.

If the supported end of the beam has such a length that the allowable adherence between the concrete and the reinforcement in this supported end is at least equal to the tensile stress in the steel arising out of the assumption of continuity, it is clear then that the assumption of a continuous beam for the end of a beam entering a wall column is legitimate.



Figs. 1 to 5—Sketch Illustrating Mr. Janni's Discussion on the Design of Reinforced Concrete Buildings

It should be borne in mind, however, that no matter what the assumption is with respect to that supported end, a certain part of the adherence between concrete and steel, in the supported end of the beam, must withstand the shear in the beam. This fact, at first, seems in contradiction with theory and a few words of explanation are perhaps necessary.

Let us suppose that in Fig. 1 *AB* is a beam supported at both ends and uniformly loaded; the shear diagram will be given by the line *CD*.

As in any section of the span the adherence between the longitudinal steel reinforcement and the concrete is proportional to the vertical shear in that section of the beam, it is plain that on the right of B, as well as on the left of A, the reinforcement should not have any tendency to slip, as there is no vertical shear in any cross-section of the supported ends of the beam.

Tests, however, show that, while for limited efforts the theoretical formula holds good, this is not the case with higher stresses, even far below the breaking point of the beam.

The above phenomenon, apparently in contradiction of theory, finds its explanation in the fact that the modulus of elasticity of the concrete is not constant, but diminishes with the increasing of stresses; so that, starting from a certain value of stress, the concrete begins to loose gradually its grip on the steel, which then finds a new position of equilibrium, extending its tensile action behind the vertical lines of supports.

The dotted line in the figure above should represent the diagram of shear. Incidentally it may be seen that the maximum actual shear is smaller than the theoretical one.

As said before, a designer, in assuming the hypothesis of the continuity of a beam entering a wall column, should take care first of the amount of shear shown by the diagram *BEFG*, and afterwards satisfy himself whether or not the remaining part of the allowable adherence is enough to withstand the moment due to the fixed end assumption.

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[1] Cons. Engr., N. Y. C.

[2] Prin. Asst. Engr., Condron Co., Struct. Engrs., Chicago

[3] Brussel & Viterbo, Cons. Engrs., St. Louis

Mechanical devices such as deformed bars, hooked ends properly made, etc., are, in a general way, good means of insuring the fixedness of that part of the reinforcement of the beam on the supports, while the vertical reinforcement of the column passing through the supported end of the beam insures its quasi-rigid connection.

Similar remarks may be made regarding the assumption of a partially continuous beam.

(2) The effect of eccentric loading on columns is an important condition of equilibrium, which should be investigated by the designer.

A column with eccentric loading is under the action of axial compression and bending; and specially for long spans carrying heavy live loads the compressive maximum stress may reach important values, the tensile stress in the steel doing likewise.

(3) A wall column being a column rigidly connected with the wall, no matter what the assumption of the beam entering the wall column may be, it has no appreciable effect upon the column itself.

In connection, however, with the idea of a beam and its supports, there is a certain point in the design of a beam entering a column, or a wall column, which is often overlooked by some designers; the point referred to is the investigation of stresses upon the support of a beam, arising out of the various assumptions made concerning the supported end of it, or in other words out of the reaction of the support.

A few words on this subject may not be amiss.

Let Fig. 2 represent the case of a beam with a supported free end, and Fig. 3 the case of a beam with a supported fixed end.

The distribution of the compression upon the support P, in Fig. 2, which is indeterminate, should be assumed, for the sake of safety, to vary according to a straight line, as shown in Fig. 4, the maximum compression fc being given by:

$$fc = 2 \frac{R}{b \times d}$$

where: R = total reaction,
b = width of beam,
d = length of the supported end of beam.

The case shown in Fig. 3 is never fully realized in practice; but the investigation of the stresses upon the support P should always be made.

This case may be represented as in Fig. 5, the reaction R being a compression and M the moment.

The diagrams to which each of these reactions gives place are shown in Fig. 5; AB being the diagram due to the vertical reaction R (compression) and CD being the diagram due to the moment M.

Adding those two diagrams together, the total diagram EF is obtained, which gives the maximum fc, the value of which can be given also by the expression:

$$fc = \frac{1}{b \times d} R + 6 \frac{M}{d}$$

where the letters have the same meaning as above.

(4) A column, which, being eccentrically loaded, has been designed disregarding such condition of loading, is a deflective unit of construction, the conditions of equilibrium of which can hardly be improved by assumptions regarding the beam supported by it.

The assumption of a freely supported beam, while it is rightly made for the sake of safety, *with respect to the beam itself,* cannot be upheld with respect to its support, especially when this support is a column whose reinforcement extends vertically through the end of the beam and above it.

The prevented movement of the supported end of the beam during its deflection gives place to a moment, no matter whether or not the designer in his assumption took care of it.

Even if the reinforcement of the column does not extend in the beam end and above it (which would be another serious mistake) the friction between the top of the column and the bottom of the supported end of the beam is such that it would tend to deflect the column toward the span, during the deflection of the beam.

In either case, therefore, a bending moment is developed at the top of the column, which should have been taken care of.

The other two assumptions, namely, continuous and partially continuous beams, which are more proper for a beam entering a column, while they would result in economy, would not improve the conditions of the equilibrium of the column.

By Mr. Wolf

In the writer's opinion it is right and proper to consider beams entering wall columns as continuous or partially so, the degree of continuity depending mainly upon the number of spans in the building parallel to the beam in question, the reinforcement of beam and the size and location of column, that is whether the latter is in an upper or a lower story.

The degree of continuity to assume in beams cast monolithic with columns is dependent upon so many conditions that exact rules are impossible of formulation.

For example a beam may be built monolithic with a wall column, but so little steel provided for negative moment at the column that when loaded the beam cracks at the top and the continuity is entirely destroyed and the beam becomes practically a simple span. It is apparent, then, that to have continuous action, steel must be provided in the top of the beam to care for the stresses developed. Just how to arrive at the amount of reinforcement necessary is a subject regarding which considerable has been written and as a result some bending moment formulas covering average conditions and which give safe results, and have been used to a considerable extent, and in addition are recommended by the Joint Committee. These are $Mwl^2/12$ at center and at support for interior spans truly continuous and for end spans $Mwl^2/10$ at center and adjoining support of end spans for both dead and live load under favorable conditions of fixity. For beams and slabs continuous moment is usually taken as $wl^2/8$ at central support and $wl^2/10$ near middle of span. (These moments of course being for uniformly distributed loads.)

A beam is said to be fixed at both ends when the tangent to the elastic curve is horizontal over each support. Now a beam framing into a large lower story exterior column which is relatively very stiff and unyielding will, if proper reinforced, be very nearly fixed and it is evident that if steel is provided for a moment of $\frac{1}{10}$ wl^2 over the supports and the center the construction will be safe, for a coefficient of $\frac{1}{12}$ applies to a fixed beam; and $\frac{1}{8}$ to a simple beam, $\frac{1}{10}$ being an average of the two coefficients.

Taking the opposite case of a slender top story exterior column supporting a roof beam, it is evident that the conditions are by no means so favorable for continuous action, for more or less bending is sure to take place in the column and the conditions of support approach those of a simple beam. For this reason, then, little or no continuous action should be depended upon in exterior beams of roof construction where light columns are used; here again the judgment of the designer must be used in determining just what moment coefficient to use.

Some designers argue against reinforcing a continuous beam over the support for the full negative moment in accordance with the formulas given above, which are for beams with a constant moment of inertia, for the reason that the negative moment can be reduced by making the beam stiffer in the middle or in other words designing for an increased bending moment at the center and a reduced moment over the supports. It has been generally accepted, however, from studies by Sanford E. Thompson and others that it is in general uneconomical to design a reinforced concrete beam stiffer in the middle than over the support. Sometimes, in order to comply with city building ordinances, it is necessary, in order to economize as much as possible, to design beams which tend to act as continuous for a lesser moment over the support than at the center, as called for by ordinance; thus making allowance for the increased stiffnes of the beam at the center. Thus, for instance, if by ordinance a moment of $wl^2/8$ is specified at mid-span for continuous beams the steel over the support should be $\frac{6}{10}$ of that at center to have the beam act as somewhat continuous, and, at the same time, be as economical as possible in the use of steel. This practice is often followed, but truly continuous action is not obtained, even if the safety of the structure is not endangered. For truly continuous action to develop it is necessary that the member be designed for the maximum theoretical moment which occurs over the support for uniform loading, and for a number of continuous spans uniformly loaded, this is $\frac{1}{12}$ wl^2. Now if less steel than is required by the above formula is placed over the support, the steel will be overstressed and cracks will tend to develop.

Some building ordinances sanction this practice by stating that the sum of the center moment and that over support should be $\frac{1}{6}$ wl^2 and that at least sufficient steel to fulfill the requirements of a moment equal to $\frac{1}{18}$ wl^2 shall be used over the support. Such recommendations have led inexperienced and commercial designers to become *"expert jugglers"* of moments, making them whatever seem best to suit their needs. In fact, more faulty designs can be traced to this practice than to any other one cause.

It does not require much demonstration to prove that continuous action cannot be obtained by using a center moment of $\frac{1}{9}$ wl^2 and a moment of $\frac{1}{18}$ wl^2 over the support (as the total moment of $\frac{1}{6}$ wl^2 requires). In such a case the steel over the supports will be greatly overstressed and cracks will occur over the supports and the beam approach the condition of a simple beam, provided, of course, that the ends are supported. Finally, it can be said that it is impossible to obtain any desired distribution of moments at center and supports by the simple variation of reinforcement. The laws of mechanics govern these things, not the whims and desires of the designer.

The effect of eccentric loading on columns should be considered, but to arrive at a mathematically correct solution of the problem is practically impossible on acount of the number of variables which must necessarily be considered. Ordinarily in buildings where the extent of the live load is very indefinite it will generally be found satisfactory to reduce the unit stress in exterior columns to, say $\frac{3}{4}$ or $\frac{2}{3}$ of the average unit stress used for interior columns, depending upon the type of construction, for to compute the stresses due to eccentricity for the great variety of conditions of loading which might occur is not justifiable. In structures in which a definite condition of live load is to be maintained at all times the effect of eccentricity should be carefully looked into. The best treatment of the subject of eccentric loading considerations on columns, in the writer's opinion, is found in *Reinforced Concrete Design,* by Faber & Bowie.

When a beam enters a wall column and is considered to be continuous or partially so, the result is that additional bending is thrown into the column or, in other words, the eccentricity is increased and provision should be made therefor in the design of the column.

In regard to the last question, "If a column is avowedly eccentrically loaded and no provision for this is made in the design should we consider entering beams as freely supported or consider them as continuous or partially continuous because of the monolithic nature of the concrete?" This has practically been answered in the foregoing. If a beam is considered as freely supported and designed as such, (there is no reinforcement placed in top of supports) the eccentricity on colums will not be so great as if the beam is designed as continuous or partially so. Therefore if no provision is to be made in column to care for the bending due to eccentricity, beams should not be designed as continuous or partially continuous at the support. This, however, is not good or economical design for it would probably, in most cases, require no more steel to design beams as continuous and to strengthen the columns to care for the eccentric load imposed, than to design the beams as simply supported and not strengthen the columns. Reinforced concrete from its very nature tends to act as monolithic or continuous and therefore, wherever possibe, advantage should be taken of this characteristic, for this is the distinguishing mark of the most advanced reinforced concrete design.

By Mr. Viterbo

(1) If beams enter the wall columns and are actually continuous over several of these columns, they should be considered as continuous. If these beams enter the wall columns and stop at these very columns, but are continuous over interior columns, they should then be considered as only partially continuous.

(2) The effect of such loading should certainly be considered in cases where the eccentricity is decidedly marked, but should be neglected where the eccentricity is small only.

(3) We are of the opinion that the eccentricity due to beams entering wall columns is lost at a very small distance from the point at which the loading is applied, owing to the fact that this very loading distributes itself very rapidly on the whole surface of the column. We therefore neglect all eccentricity due to this sort of loading, except, however, in special cases where very heavy girders are to be dealt with.

Use of Beach Shells as Concrete Aggregate □

DISCUSSED BY:
E. C. HEDRICK[1]
M. E. TINKHAM[2]
GEORGE W. MICHEL[3]
A. W. DEVOL[4]
E. E. ELKINS[5]
STEPHEN CHISLETT[6]
FREDERICK ROSS[7]

"Can you give me definite information on the reliability of beach or sea shells as concrete aggregate?"

By Mr. Hedrick

We have never seen large beach shells used as concrete aggregate but see no reason why they can not be used if run through a crusher. If used without crushing the voids would would be very large—probably as high as 90%. Crushed oyster shells (dead shells) have often been used in Florida but are not economical where other aggregates can be obtained at reasonable cost. Coquina shell is a useful aggregate for all purposes except reinforced concrete building construction. This shell is usually very small, most of it passing a ½-in. screen, and is found in beds or deposits mixed with sharp sand in about the proper proportions for concrete. Mixed with cement in the ratio of 3 to 1 it makes excellent one-course pavement. For concrete block it may be used 4:1 or 5:1 but a denser block mixture can be obtained by using sand with the coquina.

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[1] Pres., Jacksonville Concrete Co., Jacksonville, Fla.

[2] Tinkham Cement Products Wks., Palmetto, Fla.

[3] Contr., Indian River City, Fla.

[4] Cement Worker, Cocoa, Fla.

[5] Contr., Arcadia, Fla.

[6] Contr., Estero, Lee Co., Fla.

[7] Contr., Cocoanut Grove, Fla.

We have recently used the larger coquina shells—those retained on a ½-in. screen—as an aggregate for block facing, with very pleasing results. The shell are somewhat variegated in color, with a prevailing tint of brown, and when fully exposed on the surface make a most attractive block. Our method is to put the clean shells on the face plate, then a rich mixture of white cement and white sand to hold the shell, followed by the block backing as for any other block. Some skill and experience are needed to get desired results but the required efforts are well repaid. We find that a red mortar joint helps to bring out the beauty of this type of wall.

By Mr. Tinkham

I have used considerable beach shell for sidewalk, paving, sea-walls, garage floors, foundations, etc., with good results. Shell must be live, clean shell, free from loam or other foreign matter, the same as other aggregates. Some shell are much stronger than others and in this case, as in all others, the concrete cannot be stronger than the aggregate used. Shell may be used as an aggregate for many purposes, but for heavy load work I use only the best of rock. For several reasons I prefer the use of rock to shell. It is easier to handle, easier to mix and easier to tamp. Owing to the irregularity in size and shape of shell, shell concrete contains more unavoidable voids than rock concrete.

I find from experience that there is but a slight difference in the cost of concrete with rock as an aggregate at $3.00 per cu. yd., or shell as an aggregate at $1.75 per cu. yd. Owing to the flatness of many shells they contain a greater surface to be coated with sand and cement, therefore they are not equal in displacement to rock concrete.

By Mr. Michel

Sea shells mixed with portions of sand or small gravel substances, so as to fill all openings in the shells, will make a first-class aggregate, as most sea shells that I have ever seen have a smooth, "slick" outer surface, unless crushed. There should be some sort of smaller and sharper material to take hold of and fill the openings in the shell. We are using what is called the coquina rock, which before it was united and massed together was nothing more than beach shells. But in the state in which we find it now it must be dynamited out and crushed. It makes first-class material for aggregate.

By Mr. Devol

Most of the shell on the Indian River (salt water) is rather fine, and the sand is still finer. The addition of shell takes the place of coarse sand and I consider the resulting mixture superior to that made of sand and cement. It also has a more pleasing texture.

I use it whenever possible, and would not hesitate to use coarser shell. Care must be taken to see that the shell is clean and hard.

One stretch of walk 6 yrs. old, made largely of shell, shows up much better than that adjoining, made without shell.

On p. 411 of *Cement Age*, for Dec., 1910, will be found a discussion of "Sea Sand in Concrete."

By Mr. Elkins

I have had some experience with beach and sea shells as concrete aggregate, and have laid sidewalks with shells, but I never thought they made good concrete.

I have tried several times to get cement to adhere to the smooth side of the shell, but I have never yet been able to do so. Plastic cement placed on the smooth side of the shell will act about the same as if put on glass. Sea shells also contain more or less salt. With what experience I have had, I can not say I would use them for anything.

By Mr. Chislett

I have been using beach shells for 8 yrs. and have found that cement adheres to them well. The concrete stands considerable compression and is durable as well as stable and beautiful.

A 1:3:3 mixture makes a strong concrete. A 1:3:4 mixture shows some shell.

Shell-faced concrete has a handsome appearance. It adheres well, is very durable and does not discolor.

By Mr. Ross

We use beach sand for plastering and stucco work. This sand contains quite a large proportion of small shells (whole), and small pieces of broken shells, many of which are worn smooth by action of the waves. This sand gives satisfaction, and in finish gives a coarse-grained surface.

Field Examination of Concrete Sand[1]

Discussed By:
W. J. Douglas[2]
L. R. Ferguson[3]
Carl H. Fuller[4]

By Mr. Douglas

On construction work, as soon as one gets away from the large cities and from a convenient railroad track with a short haul, he is confronted with the problem of finding suitable sand, and it is often a difficult one. Assuming that he has found reasonably large deposits without excessive stripping, his problem is to determine whether or not the sand is suitable. In ordinary concrete work which need not be impervious he is not confronted with the necessity of perfection of sizing. All that remains to be done in this case is to take an ordinary bottle—although a graduated glass is preferable—⅔ full of sand, and then add clean water until the receptacle is nearly full. Shake it well and let it rest for 12 hrs. If there is less than 7% or 8% of silt, it is probably good enough for any ordinary concrete work. At the same time, however, the sand preferably should be mixed with a good quality of cement, made into pats and tested in the ordinary way. If the cement sets up in a reasonable time and does not crack and its hardening is progressive, your analysis is practically complete. Of course, it is assumed that in your exploration you have picked out fair samples.

Sometimes it is necessary to take a dozen samples in order to convince yourself that the average run of the pit is all right.

One is in the habit of picking out a bank of sand that is as near quartz white as possible and figure that the darker the bank the greater amount of clay or other foreign material. This may not always be so, however. Some of the commercial sands are of brown-black, and the darker the sand, as a rule, the cleaner it is, because the clay or other foreign material is generally lighter in color than the sand itself. On some work that we did a few years ago in which the sand-hunt was extended over several months, we learned to look for the darker sand deposits rather than the light.

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[1] Discussions by Sanford E. Thompson, John T. Simpson, H. J. Kuelling, Leonard C. Wason and William M. Kinney were published in June, 1915, issue, p. 303

[2] Barclay, Parsons & Klapp, Cons. Engrs., N. Y. C.

[3] Asst. Secy., Assn. Am. Portland Cement Mfrs., Philadelphia

[4] Cons. Engr., 2405 Wheeler St., Indianapolis

Everyone knows, of course, that sand has been used containing material which caused the concrete to disintegrate, although it may have set up hard at first. My experience has been quite extensive but I have never met any sand containing no more than 7% or 8% of silt that did not give satisfactory results. I had one experience with a sand in which I think the silt equaled 10% to 12% and which did not set up very hard from the middle of Nov. until some time in May. but it finally became excellent concrete. That, however, was not because the silt was bad but because there was too much of it.

If you are building a reinforced concrete structure which must be impervious then I would take a standard set of screens and screen the sand and analyze it according to the methods commonly given in the textbooks. As a matter of fact I believe that the average experienced concrete engineer can pick out a sand that will make dense concrete without screening, but screens should be used if they are available. Unfortunately, particularly where you are using commercial sand, there is a wide variation in different parts of the average sand-pit and one is finally dependent on the eye in getting the proper mixtures to insure density. In conclusion, the real test of sand is whether or not it sets up with the cement under ordinary conditions and that is one that can be made very quickly.

In prospecting for sand the common mistake is made to develop small pits here and there is which the sand is quite clear, containing say only 1% or 2% of silt, and as a result you will find a dozen pits on a small job where one pit would have been very much cheaper even though it contained sand with 15% silt which necessitated the installation of a washer. Recently we handled some work in which there were a number of pits and we finally decided on a single pit containing from 15% to 20% of silt. We put in an 8-in. pump with a 25-h. p. boiler and pumped water through six lines of 2-in. pipe. The water from these pipes flowed into triangular troughs into which the dirty sand was shoveled and by the time it got to the end of the trough it was sufficiently clean for concrete. It was then shoveled directly into cars and hauled a distance of ½ mi. to the site of the work.

By Mr. Ferguson

There has been no test developed which can be used in the field to determine the quality of a given sand and its suitability for use in concrete. Practically all field tests assume that the investigation must be of a physical nature, and such tests do not always indicate whether or not a sand can be successfully used in concrete. I know of a great many instances in which sands have seemed to indicate that they would make an excellent aggregate for concrete when tested by sieve analysis and void determinations, but as a matter of fact quite the reverse proved true and utter failure resulted from the use of these particular sands. The only method we know of which will determine without doubt the quality of the sand is to make a mortar test.

The question of eliminating deleterious materials from sand is a most interesting one, and as yet little has been done on the subject. Committee C-9 of the Am. Soc. for Test. Mat. has delegated to one of its subcommittees the investigation of impurities in fine aggregate, and this committee, in its investigations, is keeping in mind the possibility of correcting sands, that is, of some commercial means of improving a sand which has shown itself of poor quality. As yet the work of this subcommittee is still in its preliminary stages and has not progressed far enough to draw any definite conclusions. Its report, when it is made, however, will be of great value, I feel sure.

This question of testing aggregates, particularly fine aggregates for concrete work, has not been sufficiently emphasized up to the present time. A large proportion of the poor results obtained with concrete is due to a poor quality of sand and those building concrete structures should be made to realize the necessity of a thorough investigation of the fine aggregate which they propose to use.

By Mr. Fuller

Specifications for concrete state that "sand shall be clean, sharp and coarse," but usually fail to define what sand is. Referring to the dictionary, we find that sand is "fine particles of stone larger than powder or dust," but such academic definition is too liberal in its application for our purpose, nor is it necessary for us to enter on a technical discussion of the word. To make good concrete requires a sharp, angular grain, produced by the disintegration or crushing of a hard, crystalline rock, with all of the pulverized material washed out. Nature manufactures this product through the action of the elements and it is commercially known as "pit-sand" or "river-sand," depending on the location in which it is found.

In any case it has been deposited, where found, by the carrying and segregating action of the water, sometimes in close association with larger particles of rock known as gravel, from which it may readily be separated by means of a screen. This carrying and separating action of the water frequently deposits the larger particles or gravel in one locality, the sharp, granular particles known as sand in another and the finer pulverized material in another, often many miles apart; then again, they may be found in clearly defined layers or strata in the same locality. Where clean sand is found alone, it generally possesses all of those qualities which most nearly meet the requirements of concrete. Such sand when deposited in still water, as in a glass tumbler, shows a tendency to settle and pack, offering considerable resistance to any article, such as the blunt end of a lead pencil, thrust into it. If a sample be rolled between the fingers, it will cut or abrade the skin, owing to the sharp angular fracture of the grains. Such is good sand and these are simple, effective tests.

There is another product of the disintegrating action of water on rock, that is erroneously called sand, which is sometimes used by those who do not know how to distinguish or appreciate the difference. Usually the grains are much smaller and roll easily between the fingers, without cutting. If deposited in a glass of water that is slightly agitated by a circular motion, the particles show a tendency to float, when the blunt end of a lead pencil may easily be thrust into it. If examined under a microscope, these particles will appear rounded in shape, frequently being perfect spheres. This is quicksand and whether dirty or clean, its use should be carefully avoided in the manufacture of concrete products, it being the poorest filler or binder to be found.

Good clean pit-sand is frequently contaminated from the overlying soil or from thin veins of silt running through the sand strata, by carelessness in mining. This may be avoided by using more care in stripping the top soil. River-sand is more frequently contaminated by the silt being mixed in with it and it can only be removed by washing.

A simple test to determine the quantity of silt or vegetable matter contained in sand may readily be made by using two ordinary glass tumblers, the taller the better. Fill one of them half-way with the sand to be tested, add water until nearly full and agitate thoroughly, pouring the dirty water into the second tumbler. When the latter clears, pour off the clear water and repeat the operation until the sand in the first tumbler no longer discolors the water, care being taken to preserve all of the sediment in the second tumbler. The relative proportions of silt to sand may now be made by measuring with a finely graduated rule and reduced to percentages. Should there be a large proportion of sediment in the second class, say more than 2½% (some authorities insist that it shall be even less than this) the sand should either be washed or rejected.

To wash sand successfully is rather a tedious and difficult process unless one is equipped with the proper machinery. If supplied with plenty of clean water under pressure, a home-made washer may be constructed that will do fairly effective work. Build a shallow watertight box, of 2-in. lumber, say 18″ deep and capable of holding about 2 cu. yds. of sand. The length should be about twice the width and one end should be about 1″ lower than the other to allow for overflow and drainage. Connect the water by means of ½-in. iron pipe nipples, spaced 1′ apart around the sides of the box, entering close to the floor, and have one quick-acting valve to control the supply pipe. Turn on the water and let it run, filling the box about half full of sand. The jets of water will agitate the sand and the overflow will carry off the silt and vegetable matter. Allow the water to flow until the overflow is clear, then shut off the water, empty and recharge the box. Provision for draining the box quickly by means of a gate or plug will assist the emptying, but such an opening should be covered with a fine screen to hold back the sand.

With this outfit, two men can wash from 3 cu. yds. to 5 cu. yds. of sand per hr., at a cost of approximately 10 cts. per yd. for labor. By building two boxes, to be operated alternately, the capacity of the same labor may be materially increased, but the handling of wet sand will be strenuous work for the men.

In summing up, large grains, of a bright color, sharp and angular, freedom from large gravel or fine powder all indicate a sand of good quality, while dullness of color, small, smooth, round grains, mixed with dust or fine powder betray its unfitness for concrete.

A very simple test, in addition to visual examination, is to crush a sample in the previously wet hand. The feel will determine whether the grains are sharp and angular or round and smooth, while the dirt or silt will cling to the skin when the contents are released. Clean, sharp sand will pack in the hand but fall apart when the hand is open. Dirty sand will pack and retain its shape when the hand is opened, owing to the temporary binder of silt, while quick-sand will neither pack or hold together.

Another simple test is to sprinkle a sample on a clean sheet of window glass, tilt to a slight angle and jar slightly. Dirty sand will stick, clean crystalline sand will slide and quicksand will roll.

Correspondence: A Department in Which the *Reader* Becomes the *Writer* □

This is your department. It is informal. Use it. This is the place for letters which have either inspiration or information for the "other fellow." It is well to remember that you are usually in his position. If you are to get the good out of these columns, why not help to make them good? Write about your work. Help the Other "other fellow." □ □ □

The First Reinforced Concrete Arch in America

—A LETTER FROM JAMES W. PEARL[1]

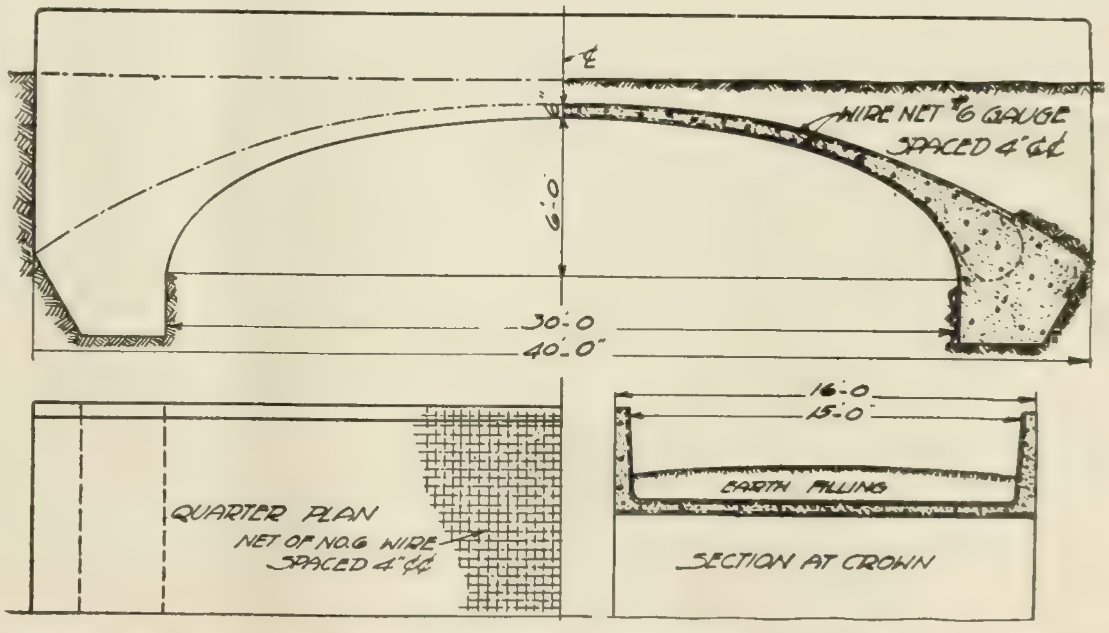
Accompanying this letter is a copy of the original contract for and a sketch of what is believed to be the first reinforced concrete arch built in America.

The contract includes the only specification prepared for the work and the original sketch was used during the period of construction and finally lost. The accompanying sketch was prepared from my records.

The bridge was constructed to open a new waterway for the tailrace from a water power; the agreement with the mill owner was not reduced to writing and after the structure was completed he refused to permit the change from the old water course unless a wider and higher opening was provided, so the arch was torn out and replaced with a steel truss having a clear span of 36′ and a higher opening.

Star brand Akron cement was used in the concrete and completion of the work was delayed until some time in Nov., 1892, when green concrete was caught in freezing weather.

The appearance of the work the following spring was very ragged and strength doubtful, but in wrecking the structure by cutting through the crown it did not collapse until the area remaining was reduced to 6″ x 6″, which justifies the conclusion that the injured concrete retained all the strength necessary for a



SKETCH OF REINFORCED CONCRETE ARCH—BELIEVED TO HAVE BEEN THE FIRST IN AMERICA stable and permanent structure. The bridge was provided with some wing walls but I am unable to give their dimensions.

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[1] Engr. & Constr., Chicago

> This agreement, made this 28th day of July, A. D. 1892, between James W. Pearl, of Benton Harbor, Michigan, of the first part, and the Commissioner of Highways and Township Clerk of Pipestone Township, Berrien county, Michigan, party of the second part:
>
> Witnesseth, That the first party hereby agrees to furnish all the material and labor, except excavations for water way, and construct and complete ready for travel a concrete arch with wire net, over Pipestone Creek at Pipestone Mills in said county and state.
>
> Said arch to be of the dimensions shown on sketch prepared by the first party for this structure, which sketch is hereby made a part of this contract, and the wire net shall consist of not less than three courses of No. 6 wire, layed with meshes not over four (4) inches square, and securely tied at each intersection with wire of smaller diameter, all imbedded in concrete to the depth of one (1) inch from surface.
>
> Said structure is to be completed on or before September 15th, 1892.
>
> The party of the first part further guarantees the structure together with all material and workmanship thereon to be strictly first class in all respects, and to allow same to be tested by actual service for one year from the date of completion thereof.
>
> In consideration of the foregoing, the second party hereby agrees to make the excavations required for waterway and pay the said first party the sum of three hundred and ninety-six ($396.00) dollars by township orders due February 1st, 1894,—provided the structure shows no defects affecting its strength or durability, after one year's service.
>
> If, at the expiration of one year from date of completion, the structure is not satisfactory to the second party, said first party shall remove same without payment for or claim for damages by reason of its construction or failure.
>
> James W. Pearl.
> Jno. Clark, Comr.
> H. E. Hess, Clerk.
>
> Approved,
> Wm. Krohne, Supt.

Stopping Cracks in Concrete

A Letter From E. H. Seaman[1]

At the present writing the walls of our boiler pit, which are 8″ to 10″ thick and the floor, which is 6″ thick, are under a 2-ft. 6-in. head of water and the sump, which is about 3′ below the floor, is under about a 5-ft. head. The water is standing outside the walls and within 3½″ of the top.

The floor developed three cracks and the base of the boiler developed two, although the latter is over 18″ thick. Leaks also developed at various points where walls and floors joined. All leaks with minor exceptions have been repaired by cutting into the walls or floor about 1″ and driving sheet lead into leading cracks until all leakage was stopped and then joint was closed by Smooth-On cement No. 7.[2] To date all repairs seem to be effectual.

No leaks of any kind developed in the walls or floor except the cracks above noted, and the building has remained perfectly dry at all points except where cracks developed.

Concrete Products in Cuba and in the United States

A Letter From W. P. Butler[1]

In Cuba, last year, building operations were at a standstill. The new President's Palace in Havana, which is to cost over $3,000,000, had the frame of reinforced concrete nearly completed and I was told that a considerable quantity of cast stone was to be used in the finishing. Reinforced concrete work meets there with popular approval, as it lends itself so much to the Cuban desire for strength, solidarity and permanence in architectural construction.

The Cuban, like his ancestor, the Spaniard, in his architectural tastes, runs to broad areas of plain surfaces with the surrounding trim made up of a wealth of elaborate detail requiring the skill of artistic designers and skilled workmen to execute the designs in plaster or cement. Few American workmen in ornamental concrete have acquired the skill so commonly known in Cuba in the execution of art-cement detail. Most of this work is "dry-process" work tamped into plaster molds or is cast in glue or sand. In making sand-cast stone the Cuban has attained great skill and excellence of workmanship. Many banks, club houses, churches, palatial residences, business buildings and public buildings in all the leading cities of Cuba are built wholly or in large part of cast stone. Among these structures is the Chamber of Commerce at Havana, the largest building in Cuba. Purdy & Henderson, Havana, use the Stevens cast stone process, while the T. L. Huston Contracting Co., Havana, uses the Butler cast stone process.

The latter company completed, in 1914, a seven-story business building (the highest in Cuba) of cast stone, while next to it is a four-story building, also of cast stone. Both buildings are a credit to their makers and to cast stone as a building material of superior excellence when made by workmen who have skill and conscience, and put both into their work.

The concrete block industry is fast dying out in the U. S. because of poor work. Subsequent observations in many states have justified that prophecy. In many towns and cities in Wis., Minn., Ia., Neb., Mo., Kans., Tex., N. M., Ariz. and Cal., which I have visited recently, I find the business of making all kinds of cement products entirely dead and gone or reduced to a pathetic vanishing point. I say pathetic because this universal decadence of what could be and should be a successful and enduring business, is the direct result of ignorance, incompetence and lack of conscience, which are today undermining and lowering the standard of workmanship in every building trade and in every section of this country. The cement products business has deliberately committed hara-kiri in this country though one will, at long intervals, find men still in the business, growing, prospering and proving to the world that the fault is not with the business but with the men who run it, and that success can be achieved by men who will discard old methods, old machinery, old ideas, and cleave to the new in thought and method and conserve efficiency in management and honesty in operation to the end that the product "speaks for itself" in terms of excellence and endurance.

The public does want good concrete stone. It *will* pay for it. It is wanted in every city and town in America and if some man in every town would make good material he would succeed.

The common, cheap, dishonestly made dry-process block must go—yes, it has gone! In its place there should be a high grade cement block or brick and the superior product, cast stone, for high-grade work. There is a field for all—a demand for each.

We in the U. S. ought to attain to as much skill and as much conscience in the manufacture of concrete products as has been attained by many cement workers in Canada and Cuba but, though there are a few notable exceptions, such has not been the case among a vast majority of cement workers in this country.

Germany, Sweden and Denmark have developed a great skill in the manufacture and use of concrete shingles and roof tile. Concrete tile are being made and laid economically in a few localities in this country, but their use is by no means as general as it should be.

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[1] Electrical and Mech. Engr., Wantagh, N. Y.

[1] Minneapolis

[2] Smooth-On Mfg. Co., Jersey City, N. J.

Organizations □

American Concrete Institute, Charles L. Fish, Secretary, Harrison Building, Philadelphia, Pa.

American Concrete Pipe Association, Secretary, E. S. Hanson, 538 S. Clark St., Chicago.

American Highway Association, I. S. Pennybacker, Jr., Executive Secretary; Colorado Bldg., Washington, D. C.

American Road Builders' Association, Secretary, E. L. Powers, 150 Nassau St., N. Y. C.

Association of American Portland Cement Manufacturers, Percy H. Wilson, Secretary, Bellevue Court Building, Philadelphia, Pa.

Cement Products Exhibition Co., 208 S. LaSalle St., Chicago, Ill.; Robt. F. Hall, Secy., Chicago Cement Show, Coliseum and Light Infantry Armory, Feb. 12-19, 1916.

Iowa Association of Cement Users, Secretary, H. H. Dean, Glenwood, Ia.

Mid West Cement Users' Association, Secy.-Treas., Frank Whipperman, Omaha, Neb.

Pan-American Road Congress, Oakland, Cal., Sept. 13-17, 1915; Gov. George W. Gates, Vermont, Chmn. Ex. Com.

Second National Conference on Concrete Road Building, J. P. Beck, Sec'y, 208 So. LaSalle St., Chicago. Chicago, Feb. 15-18, 1916.

Pan-American Road Congress

An announcement of the Pan-American Road Congress says that invitations are being sent by the Executive Committee, the chairman of which is Charles W. Gates, governor of Vt., to the governors of each state, to the lieutenant-governors of the Canadian provinces, and to the presidents of the South American republics, asking them to attend in person and to name delegates to the Pan-American Road Congress which is to be held in Oakland, Cal., Sept. 13-17, 1915. This Congress will be held under the joint auspices of the American Road Builders' Assn. and the American Highway Assn., in cooperation with the Tri-State Good Roads Assn., the membership of which covers the states of Cal., Ore. and Wn.

It is expected that delegates from every state and Canadian province, and a large number of the South American republics will attend this great gathering in the interest of Good Roads.

Among those who have already accepted assignments and their subjects on the program are the following:

G. P. Coleman, State Highway Commr. of a., "Convict Labor for Highway Work"; Wm. H. Connell, Chf., Bur. of Highways and Street Cleaning of Philadelphia, Pa., "Dust Suppression and Street Cleaning"; Geo. W. Cooley, State Engr. of Minn., "Road Drainage and Foundations"; A. W. Dean, Chf. Engr., Mass. Highway Comm., "Maintenance, Materials and Methods"; A. B. Fletcher, State Highway Engr. of Cal., "Organization and System in Highway Work"; W. S. Gearhart, State Engr. of Kans., "Highway Bridges and Structures"; Nelson P. Lewis, Chf. Engr., Board of Estimate and Apportionment of N. Y. C., "Highway Indebtedness: Its Limitation and Regulation"; L. W. Page, Director, U. S. Office of Public Roads, "The History and Future of Highway Improvement"; Frank F. Rogers, State Highway Commr. of Mich., "Roadway Surfacings"; Prof. L.S. Smith, Univ. of Wisconsin, "The Educational Field for Highway Departments"; Col. E. A. Stevens, State Commr. of Public Roads of N. J., "The Essentials of Proper Laws for Highway Work"; W. D. Uhler, Chf. Engr., Pa. State Highway Comm., "Resurfacing Old Roads."

Among those who will preside at the sessions of the Congress are the following: Fairfax Harrison, Pres., Southern Ry. Co.; W. A. McLean, Chf. Engr. of Highways and Commr., Ontario Public Roads and Highways Comm.; Col. W. D. Sohier, Chmn., Massachusetts Highway Comm.; Geo. W. Tillson, Cons. Engr. to the Pres. of the Borough of Brooklyn, N. Y. C.

International Engineering Congress, 1915

The Materials of Engineering Construction will receive special attention in the proceedings and discussions of the International Engineering Congress to be held in San Francisco, Sept. 20-25 next.

The field will be treated under 18 or more topics, covering: Timber resources; preservative methods; brick and clay products in general; life of concrete structures; aggregates for concrete; waterproofing; volume changes in concrete; world's supply of iron; life of iron and steel structures; special steels; status of copper and world's supply; alloys; aluminum; testing of metals, of full sized members, and of structures.

Some 25 papers are expected, prepared by authors representing five different countries. The list of authors includes many of the most eminent names in this field of engineering work throughout the world.

These papers, together with discussions contributed by leading American and foreign engineers, will be published as Volume 5 of the *Transactions*, and will be illustrated with charts, diagrams and halftones.

For full particulars apply to W. A. Cattell, secy., 417 Foxcroft Bldg., San Francisco, Cal.

Second National Conference on Concrete Road Building

Announcement is made of the organization of seventeen sub-committees for the Second National Conference on Concrete Road Building, to be held in Chicago, Feb. 15 to 18, 1916. Each committee is to investigate and submit a report upon a specific topic in connection with the construction of concrete roads. The committees are made up of college and university professors, state, city and county authorities, engineers and contractors. The committees are as follows:

1—Drainage and Preparation of Subgrade; 2—Economical Widths of Pavement and Shoulders; 3—Problems of Design, Thickness, Crown and Grade; 4—Aggregates; 5—Handling and Hauling Materials and Water Supply; 6—Organization of Concreting Crew; 7—Proportions of Materials and Consistency of Concrete; 8—Mixing and Placing Concrete; 9—Reinforcing; 10—Joint Location and Construction; 11—Expansion and Contraction; 12—Finishing and Curing; 13—Construction of Shoulders and Curbs; 14—Methods and Cost of Maintenance; 15—Form of Specifications; 16—Costs of Construction; 17—Estimating and Inspection Problems.

The Advisory Committee has again elected Dr. W. F. M. Goss, Dean of the College of Engineering of the Univerity of Illinois as chairman and J. P. Beck as secretary.

The preliminary announcement says in part:

> The First Conference held in Chicago in February, 1914, proved an unqualified success and by resolution the Advisory Committee was empowered to make arrangements for a future conference. Many matters came before the first Conference for the consideration of which further investigation and study was considered advisable. The large attendance and deep interest manifested at the sessions, emphasize the need for such further deliberations as will be brought out by the Conference in Feb., 1916. In the period intervening between the two meetings, new sources of information have been opened and a new fund of engineering experience will be available. The rapid extension of the use of concrete for the construction of roads, street pavements and alleys, which occurred prior to 1914, has been even more marked in the year succeeding the first Conference and indications point to a continued expansion in the adaptation of concrete to road construction.
>
> The program for the second Conference will follow the general lines worked out so successfully for the first meeting with a few changes dictated by new conditions.
>
> A cordial invitation is extended to all interested in highway improvements to correspond with the Secretary and to attend and participate in the Conference.
>
> The Secretary's office is at 208 South La Salle Street, Chicago.

New Books

Reinforced Concrete in Practice: By A. Alban H. Scott, cloth, 7½″ x 4¾″, 188 pp., 130 illusts. and diagrams and two folding tables. D. Van Norstrand Co., $1.25 net.

This volume is one of a series of engineering works published by Scott, Greenwood & Son, London. It treats of the use of concrete in buildings in an interesting way and is not too technical for the lay reader.

The Cost of Power—A Big Business Problem: By Gerald B. Gould, M. A., and Carleton W. Hubbard, B. S., leather, 6½″ x 4½″, 126 pp., illust. Fuel Engrg. Co., of New York, $2.00 net.

The manufacturer who is progressive is insisting on a better knowledge of his fuel, which is one of his largest expense items. This book deals with the methods used in testing coal for its heat value and shows what careful selection of fuel means in terms of money. The point is made that the only scientific way to purchase coal is on the basis of the heat units it will yield as shown by careful tests.

Building Code — Recommended by The National Board of Fire Underwriters, N. Y. C. Cloth, 7½″ x 5¼″, 326 pp., illust., Fourth Edition, 1915.

The work of this Board is too well known to need comment. The suggested code embodies recommendations for the erection of fire safe buildings. It is the belief of the publishers that this book offers a safe, practical, conservative ordinance representing the best modern engineering practice. This new edition contains explanatory notes and illustrations showing construction details. Attention is called to a "Suggested Building Ordinance for Small Towns and Villages," also published by the National Board of Fire Underwriters for the use of municipalities too small to require an elaborate code.

Masonry: By Malverd A. Howe, C. E., cloth, 9¼″ x 6″, 100 pp., 115 illust., John Wiley & Sons, $1.50 net.

This book is written primarily as a concise textbook of masonry for use in the class room.

That it has a broader scope than that use is evident to the careful reader. Stone masonry, including modern methods of quarrying and stone cutting, is discussed briefly in about 50 pages.

A summary of the manufacture of brick and tile and their use occupies about the same space.

The manufacture of lime and cement and the making of mortars are treated briefly, and concrete masonry is discussed in about 50 pages. Prof. Howe has packed into a few pages a remarkably varied amount of information and includes a description of the more advanced equipment used for special work. A chapter on specifications completes the book.

A noticeable feature is the very complete references to other engineering works as sources of supplementary information on every subject treated.

Materials of Construction: By Adelbert P. Mills, cloth, 9¼″ x 6¼″, 682 pp., 345 illust. John Wiley & Sons, price $4.50 net.

This work covers the manufacture, properties, and uses of the more common materials of engineering construction in a comparatively concise and thoroughly modern manner. It is intended to be simply a textbook and reference work of somewhat elementary character, not a treatise exhaustively covering the very broad field of "Materials of Construction." An effort has been made to present the material in a definite, concrete form, the necessity for the exercise of discriminatory judgment upon the part of the inexperienced student being obviated by conclusions drawn by the author.

The consideration of each material or class of materials is prefaced by a discussion of the ordinary applications of that material in engineering construction, followed by a study of its manufacture or natural occurrence, and concluded by a discussion of physical and mechanical properties in their relation to the uses of that material in construction.

The author believes that the testing of materials can be handled adequately in the laboratory only, and it is assumed that a laboratory course will parallel and supplement this textbook. Therefore, testing of materials has been treated only when inseparable from a discussion of their properties as revealed by laboratory tests.

Books Received

Plain and Reinforced Concrete Arches—By J. Melan and D. B. Steinman, C. E. Cloth, 9¼″ x 6″, 162 pp., illust. John Wiley & Sons, $2.00 net.

Placing Concrete Under Difficulties

The casting of an elevated open aqueduct as a part of an irrigation system in Alberta, Can., with an invert consisting of a catenary section 23′ across, designed to carry a depth of 8′ 8¼″ of water at full flow, aroused some doubt as to whether or not the 5-in. slab could be poured successfully without pockets or loss of density.

H. B. Muckleston states that the solution of the difficulty proved to be in the method used in pouring as follows:[1]

> The invert was poured in 80-ft. sections. The concrete consisted of fine aggregate kept as wet as possible without separation of the materials. Pouring was done as rapidly as possible alternately from each side of the shell, causing a backward and forward movement of the mass crosswise of the shell, until the later was filled.

This method made certain the embedment of the reinforcing and the elimination of voids.

Pre-East Concrete Railway Bridges

Leroy M. Schrufer describes the design and manufacture of concrete slabs which are assembled to form flat slab bridges up to 30 ft. span, for the Pennsylvania Ry.[2]

The feature of this work is the casting floor which is a 12-in. concrete pavement over an 18-in. fill of cinders. Three sides of this floor are curbed to form a bearing for form braces. Forms for the slabs are erected and concrete poured directly on the concrete. The finished units are handled by locomotive cranes and are quickly placed. The bridges are designed to carry the heaviest class of traffic.

Concrete Used 200 B. C.

A concrete aqueduct constructed 200 B. C. at Tarragona, Spain, is described by John R. Rippey.[3]

This structure is 22 mi. long and portions are carried on viaducts. At one point the viaduct is 123′ high and consists of two tiers of arches of 22-ft., 6-in. span.

Stone, brick and concrete were used in the structure and broken brick were used as aggregate for portions of the concrete. Little remains of the waterway, but some parts of the supporting structure are remarkably well preserved. The Spanish government is taking steps to protect the structure.

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[1] *Eng. News*, July 8, 1915, p. 58

[2] *Eng. News*, July 15, 1915, p. 125

[3] *Eng. News*, July 8, 1915

The Unit Construction of a Portland Cement Mill Building

By D. C. Findlay, C. E.[1]

That there are instances in which the newly developed system of unit construction displays considerable superiority over the old method of formwork and casting in position, where duplication of units occurs, has been demonstrated by several notable pieces of construction in recent months.

The following information relates to an application of the "unit type" of construction used on a mill building for the Vancouver Portland Cement Co., Victoria, B. C. It is a type designed to overcome several serious difficulties that stood in the way of using ordinary methods of concrete construction. The building, as built, is of the "saw-tooth" type.

It will be noted from the sectional elevation of the building shown in Fig. 1 that the total height from floor to bottom of beam is 27′ 3″; this height alone would require rigid posts to support the forms, providing the ordinary method had been adopted. An additional handicap to ordinary construction would have been in maintaining the two rotary coolers (shown in section in Fig. 1) in continuous operation, which was absolutely necessary in the present instance. These coolers handle clinker from the rotary kilns at a temperature of about 1,500° F., and this would have prevented the use of any timber forms close to the shell. A further handicap to ordinary construction would have been that presented by a railway track in the space between the two coolers, it being necessary to keep the track clear at all times, as it was in constant use.

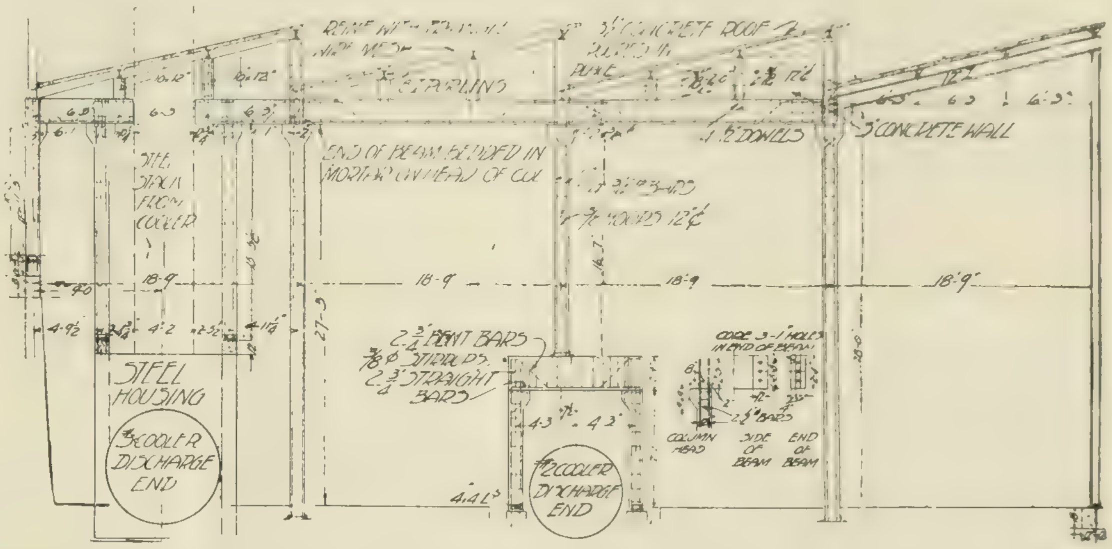

Fig. 1—Section Through Kiln Roof of Concrete Mill Building for Vancouver Portland Cement Co., Victoria, B. C.

For these reasons it was decided to cast the various members on a casting floor outside of the building, and to erect them into position in a manner somewhat similar to that used in the erection of square timber. A casting floor about 30′ wide and 100′ long was carefully leveled up and floored with tongued and grooved dressed lumber 2″ thick. A special type of telpher track was built on each side of the floor to handle the long beams and columns to be constructed. Fig. 2 shows a view of the casting yard.

The tracks were supported by bents at 18′ centers, carrying 20-lb. rails, forming a runway for a two-wheeled carriage having grooved wheels overhung on a ball-bearing shaft to which was attached a frame carrying a 5-ton chain block. A 29-ft. length of 7⅛-in. H-section was used to attach the chain blocks at either end. When a unit was ready for transfer to the storage yard it could be lifted high enough to clear the other forms by means of steel bars inserted in holes left in the concrete, and could then be run out on the track, Or, when a unit was required in the structure, the same method was used to place it on a flat car on a track which crossed under the runway.

A motor-driven ½-yd. Ransome concrete mixer[2] was located at one end of the floor high enough to allow the concrete buggies to run on plank on top of the unit forms. Sand and gravel were scraped off of scows and deposited at the mixer.

DESIGN OF UNIT FORMS AND MEMBERS

The details of the removable forms for casting the beams and columns and a detail of the design of the beams and columns are diagramatically shown in Figs. 3 and 4. The beams were made 1′ x 1′ 9″ x 18′ 5″ long and reinforced with three ¾-in. bent and two ¾-in. straight bars hooped every 12″ as shown in

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[1] Cons. Engr., Victoria, B. C.

[2] Ransome Concrete Mchy. Co., Dunellen, N. J.

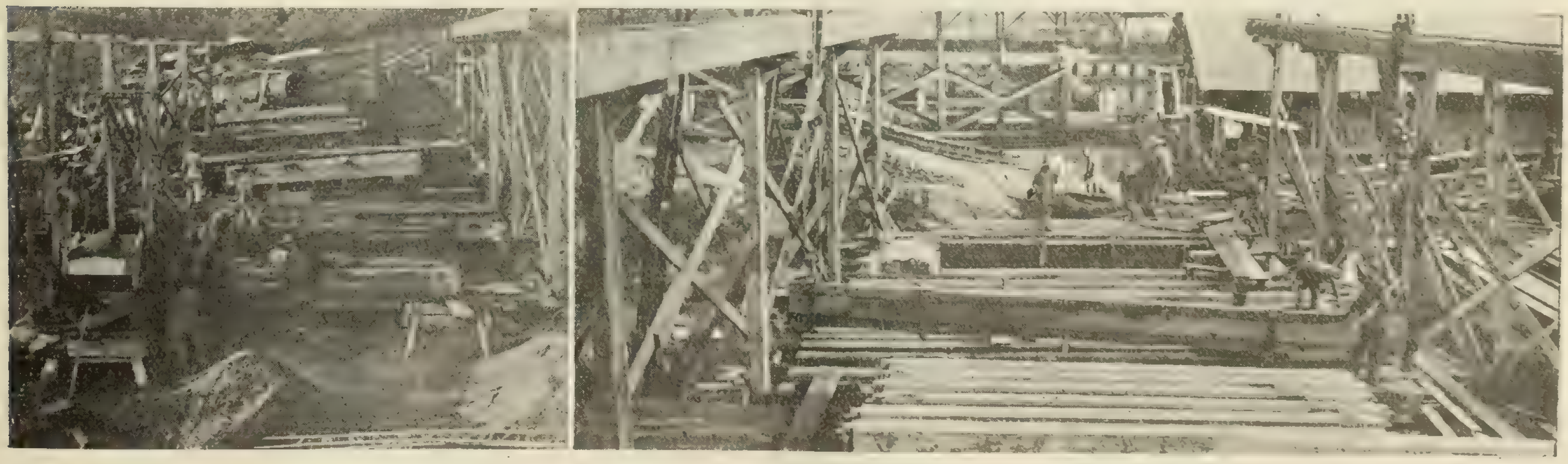


Fig. 2—Views of Casting Floor Showing Concrete Mixer, Telpher Ttacks and Unit-Cast Concrete Beams and Columns

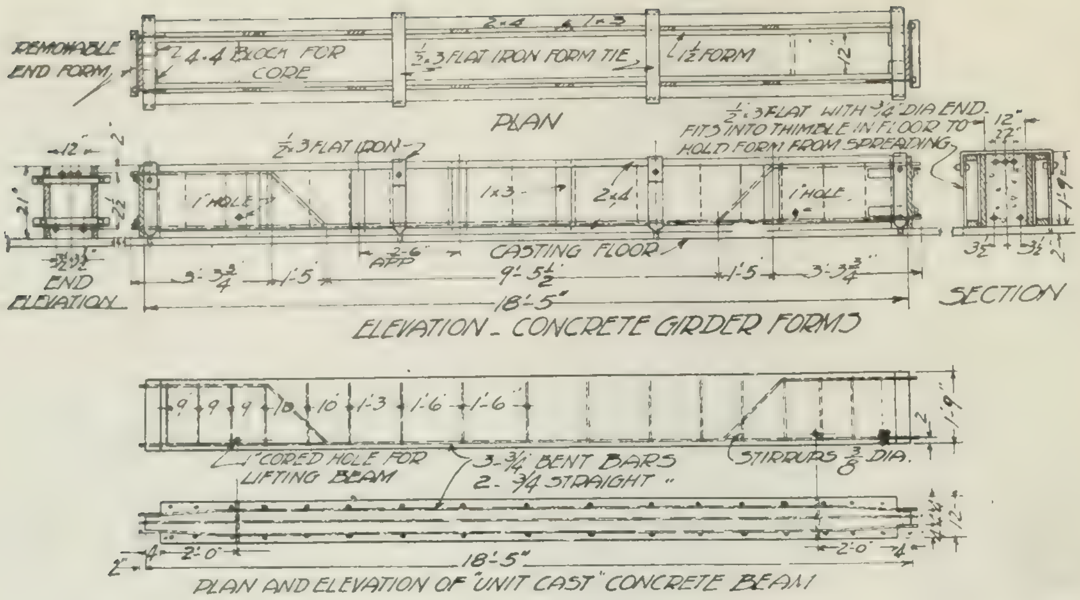


Fig. 3—Beam Molds and Details of Unit-Cast Concrete Beam

Fig. 3, the ends of the bars projecting 2″ at each end. The column size and reinforcement are shown in Fig. 4. One-in. holes were made in the beams and columns near the ends, as shown, for lifting purposes and in the columns two ¾-in. bolts, threaded at both ends, were cast into the columns for attaching the 4-in. x 4-in. angle irons.

The forms were made easily collapsible and were held in place by the ½-in. x 3-in. irons shown in Figs. 3 and 4, slipping into holes in the floor. This held the forms always in rigid alignment and ensured straight columns.

The reinforcing steel was made up and securely tied and placed in position as a unit.

CASTING THE UNITS

The concrete was a 1:2:3 mixture for the columns and the beams.

By casting the units in a horizontal position careful tamping of the concrete was assured and the finished unit was very free from defects.

The units were usually allowed to remain undisturbed for about 7 das. before being moved into the storage pile, where they remained until ready for erection.

ERECTION OF UNITS

The footings for the columns were excavated and concrete poured in place to 1′ below floor grade. Four ¾-in. bolts were set for attaching the 4-in. x 4-in. angle irons.

The columns were erected by means of a gin-pole and hand winch, as the site was too crowded to allow the use of a derrick. Likewise the gin-pole picked the beam up by the middle and set it on top of the columns as shown in Fig. 5. Before landing in position a thin layer of mortar was placed on the head of the column to form a uniform seat, and a form was placed around the joints. The projecting column and beam steel and the dovetailed ends of the beams were then grouted in with a wet 1:3 mixture.

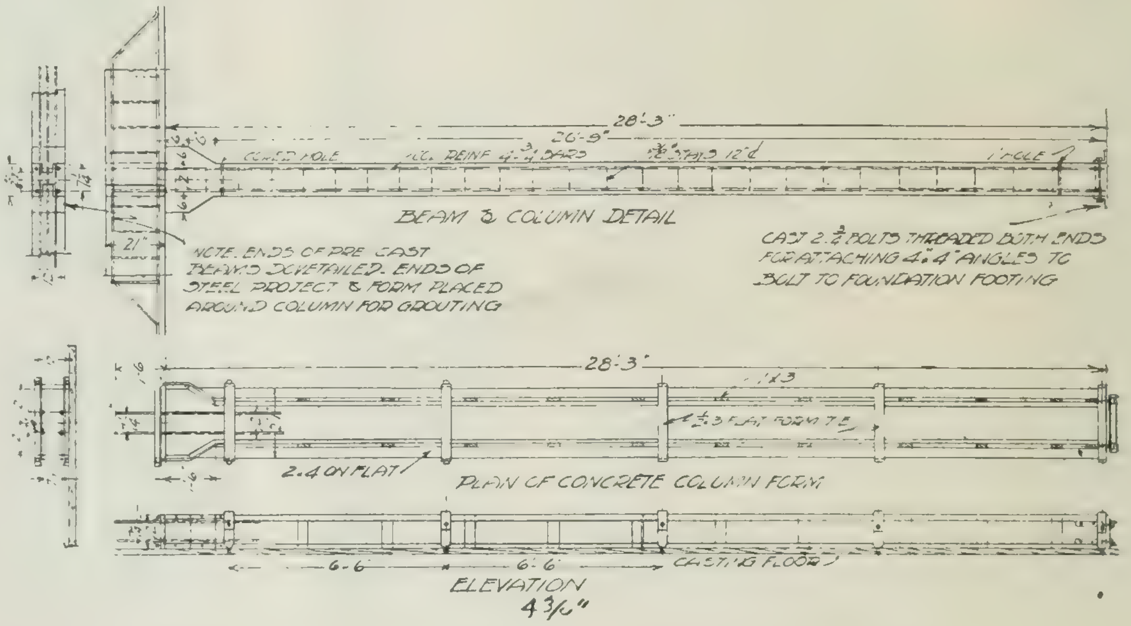

28-3"
26-9"
CORED HOLE
LONG. REINF 4-¾ BARS
⅜ STAYS 12"
1" HOLE
21"
BEAM & COLUMN DETAIL
NOTE. ENDS OF PRE CAST BEAMS DOVETAILED. ENDS OF STEEL PROJECT & FORM PLACED AROUND COLUMN FOR GROUTING
CAST 2-¾ BOLTS THREADED BOTH ENDS FOR ATTACHING 4"-4" ANGLES TO BOLT TO FOUNDATION FOOTING
28-3"
1×3
½-3 FLAT FORM TIE
2-4 ON FLAT
PLAN OF CONCRETE COLUMN FORM
6-6
6-6
CASTING FLOOR
ELEVATION
4¾"

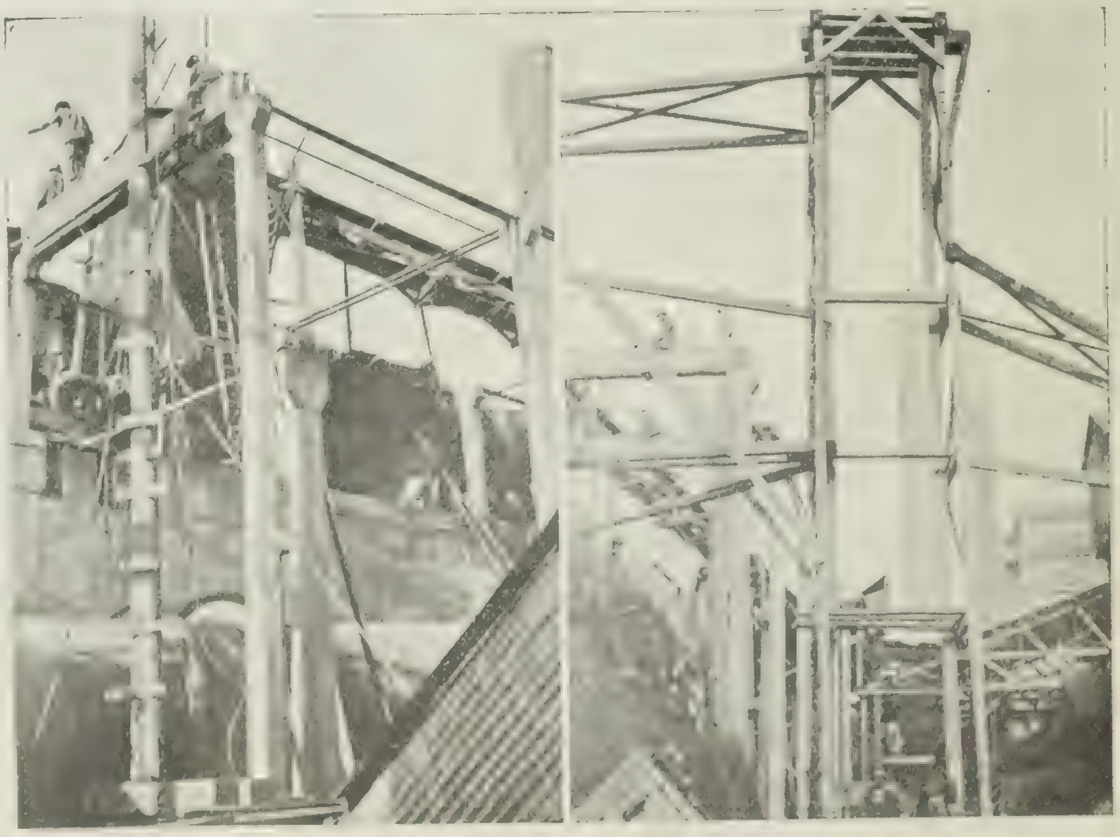
Fig. 4—Column Mold and Details of Unit-Cast Concrete Column

ROOF CONSTRUCTION

After the beam was in place, a collapsible form was set up on top of it, and the roof truss was poured in place. Details of the roof truss are shown in Fig. 1, consisting of three buttresses 10″ x 12″, connected by a 3-in. reinforced wall. Anchor bolts were set for attaching the 8-in. I-beam purlins to carry the roof slab. These buttresses were bonded to the beams by ¾-in. dowels grouted into holes cored in the beam. Figs. 7 and 8 show the roof purlins in place for one section.

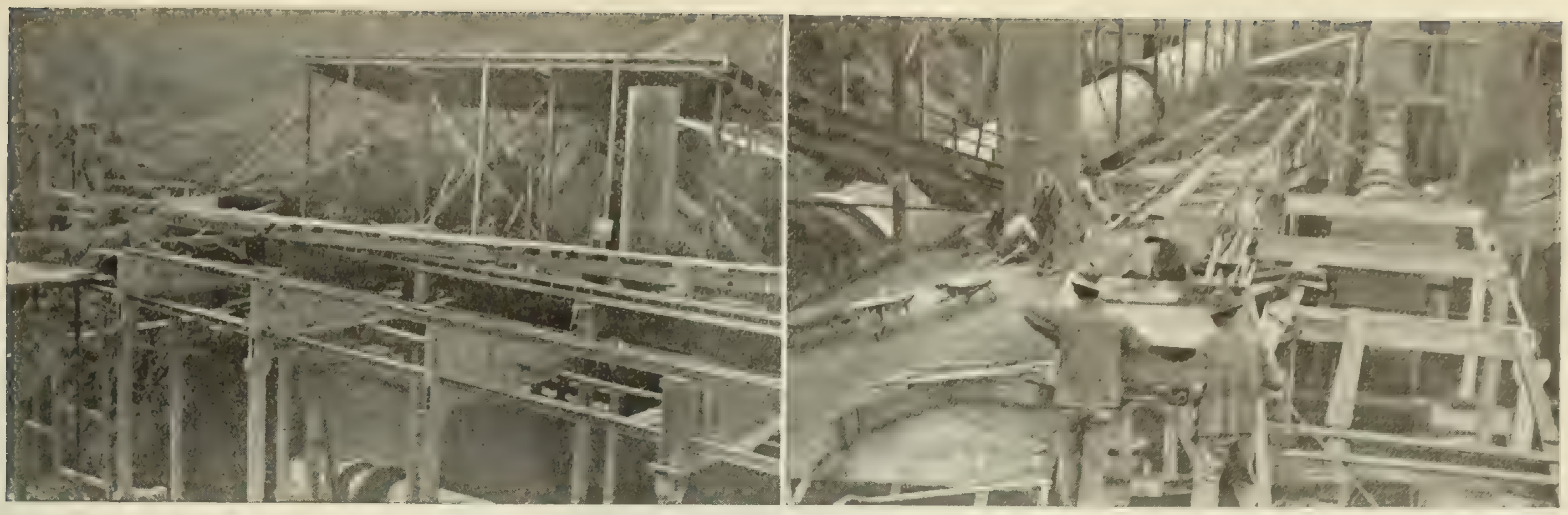
The forms for the roof slab were made in sections and were carried by the bottom flanges of the I-beams. By beveling the ends, the web of the I-beam was encased, leaving only the bottom flange exposed.

Concrete for the roof slab was mixed by the mixer at the casting



Figs. 5 and 6—Views Showing the Erection of the Units

Fig. 5 shows the manner of erecting a unit-cast beam with a gin pole, while Fig. 6 shows the hoisting tower and units under erection



FIGS. 7 AND 8—VIEWS SHOWING ROOF TRUSS AND PURLINS

Fig. 7 shows also the concrete hoisting tower and track on the finished roof, while Fig. 8 shows the concrete car on the track in the process of being dumped

floor and the 1-yd. Koppel side-dump cars[3] were hauled by an electric winch to a tower at the edge of the building. A second winch picked the car and a section of track up bodily and elevated them about 35′ to the level of a track on the roof where the concrete was dumped into a box and distributed by wheelbarrows. Fig. 7 shows the tower and track, while Fig. 8 shows a car of concrete being dumped.

The roof slab was 3½″ thick and was finished with ½″ of 1:2 mixture and troweled smooth. A concrete rain gutter was molded in place, with a slope towards the edge of the building to run off the water.

This type of construction eliminates practically all the formwork and waste of lumber, as the beam and the column forms were used repeatedly, as were the forms for the roof truss and the collapsible roof slab forms. Attention is called to the method of carrying the columns. Excellent results were obtained at a cost of about 70% of the estimate of a similar job built in place.

The work was designed and erected under the direction of the writer.

Three Sewage Treatment Plants for Residences

That the smaller sewage treatment plants may vary greatly in design and construction is well brought out in an article by R. F. McDowell.[1] He describes three typical plants, A, B and C.

Plant A serves a summer residence fronting a lake and is used during the bathing season only. Conditions made a gravity system impractical and a motor-driven compression plant was installed to operate an ejection.

The sewage treatment plant provides for 50 people at the rate of 50 gals. per day, and consists of a two-story reduction tank and two rapid sand filters covered with glass to assist in rapid drying of the sediment. Course filtering material was used as a high degree of purification was unnecessary. Cost about $2,000.

The estate on which filter B was installed was about 2 mi. from the lake and discharged into a very small stream, at times dry, which affords no dilution of the effuent. The area and the topography of the ground suggest sub-soil absorption but as the soil is a heavy clay it was necessary to install sand filters.

The plant was designed to treat a maximum daily flow of 4,500 gals. and is used throughout the year.

It consists of a screen chamber, a two-story reduction tank, a dosing tank and two intermittent sand filters. The tanks are built as a unit of reinforced concrete and the filters are about 200′ away. They are constructed partly in an excavation with concrete walls and provide 3′ of filtering material. Cost about $1,200.

Plant C provides for only 10 or 12 persons and is made simpler in construction. There is no watercourse for the discharge but the soil is good sandy loam.

The plant is on a steep hillside and consists of a septic tank, a dosing tank and 600′ of tile laid along the hill with open joints. The tile are in two lines and a small concrete gate chamber permits cutting out either line. Cost about $350. All three plants have operated in a satisfactory manner.

Hotel Traymore, Atlantic City

Hotel Traymore at Atlantic City, N. J., is described[1] as one of the largest and most complicated structures yet erected of reinforced concrete. It is 18 stories in height, built on wood piles, and is surmounted by reinforced concrete domes.

Tests of piles in sand, several types of floors and columns used, including many offset columns, heavy cantilever girders which carry one or more stories and the large domes and galleries involved unusual design and construction features.

The main building is 140′ x 520′, and reaches a height of 238′, being exceeded in height by only one reinforced concrete building.

The construction was very rapid, having been started Sept. 1, 1914, and while not complete it was put in use June 1, 1915, when the Am. Soc. for Testing Materials held its annual meeting there. Most of the work was done in the winter, involving special precautions; the material bins were kept heated by steam coils. Concrete was made of washed sand and gravel.

"Hap" Hazzard in Charge of a Mixer Gang

Our friend, Hap. Hazzard, was recently employed to do the concrete work in a building of considerable size in Everytown.

He employed for the work a continuous mixer of somewhat erratic habits, due to long association with its owner.

Sez Hap: "Too much bother to patch her up and keep the bins full, we can do the trick easier.

"Tony, dump two big barrows of gravel; Jim, spread a bag of cement on top; make a big pile that way and when we get going shovel the whole business in through the gravel bin and keep 'er coming the same way."

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[1] Asst. engr. with R. Winthrop Pratt, cons. eng., Cleveland, in *Eng. News*, July 8, 1915

[3] Orenstein-Arthur Koppel Co., Pittsburgh

[1] *Eng. News*, July 1, 1915, p. 18; July 8, p. 80; *Eng. Rec.*, July 3, 1915, p. 11

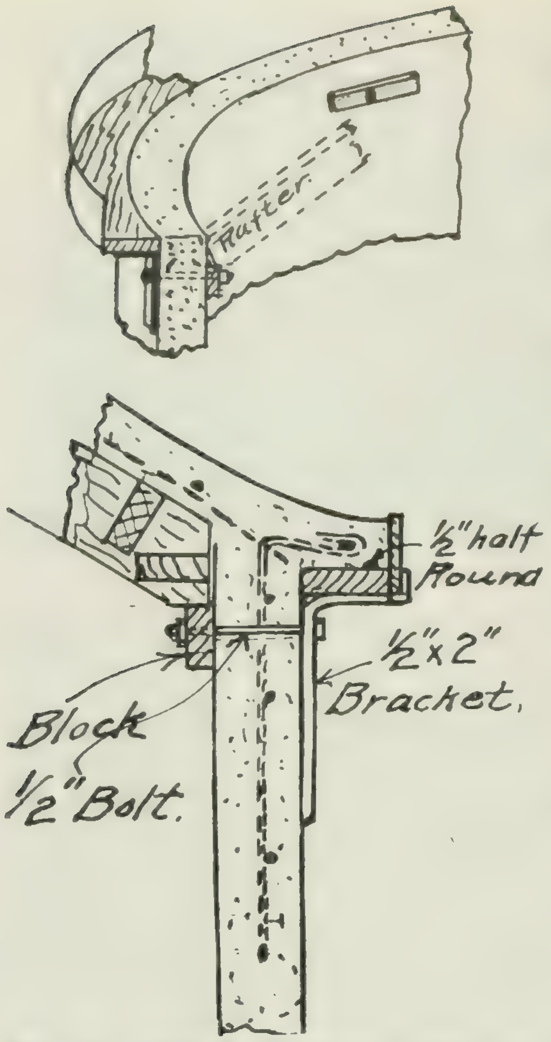

Fig. 16—Diagram Showing Cornice and Roof Form Supports

Building Concrete Silos

(Continued from p. 62)

a support for the cornice form, and also for the roof forms, as shown in Fig. 16.

Fig. 17 shows roof framing and method of applying expanded metal where a set of roof forms is not available. In place of the curved, framed members shown, 1-in. x 2-in. furring can be nailed to the rafters spaced about 12″ o. c. to support the metal, but if this method is followed, the rafters should be closer together. The illustrations make extended explanation unnecessary.

Sectional Roof Form.—The contractor will find a sectional roof form much more convenient and economical. There are on the market a number of good roof forms, most of which are made of metal and give good service. The following suggestions are for the man who prefers to build his own forms.

At Fig. 18 are shown a plan and a section of the frame. The drawing shows an 8-section form, but the directions hold for any number of sections or for any size or pitch of roof. The rafters are 1″ x 6″ and the purlins 1″ and 2″ thick as shown to provide solid nailing and economize weight as much as possible. The rafters are cut exactly as for any roof, except that they are kept short at the top to allow for meeting on

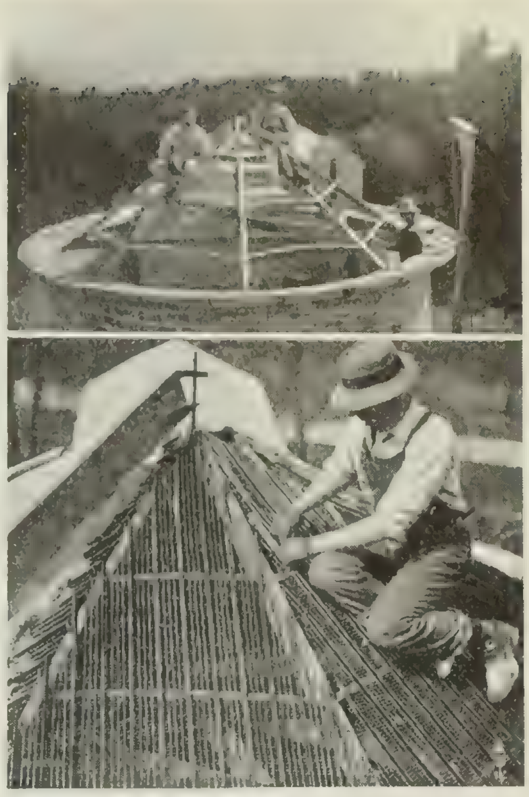

Fig. 17—Above—Frame for Concrete Roof; Below—Expanded Metal in Place, Concreting Begun

tapered block. The ventilator can curved purlins is shown in the section Fig. 18. The best way is to lay out be set in place on top of forms. Galvanized iron or a concrete pipe with storm cap can be used.

The method of laying out the a full size section on a floor and determine the position of the purlins, then a line drawn perpendicular to the rafter intersecting the vertical axis of the roof gives the proper radius with which to strike out a purlin at that point.

Light wood strips are framed up as shown and the forms covered with sheet metal.

In setting the forms at least two joints should be wedged apart and a center block prepared with a wedged section so that it can be removed. A little judgment will prevent any trouble in removing forms.

The roof should be reinforced with rods or light rods and wire mesh, see Fig. 19.

The concrete should be about 3″ thick with the reinforcing 1″ from the bottom of the slab. Gravel should contain no stone of more than 1-in. diameter and materials should be well graded. Concrete mixed 1:2:4 with hydrated lime added equal in bulk to one-tenth of the cement will, with care in placing, produce a tight roof without further waterproofing. (1/10 by volume is equal

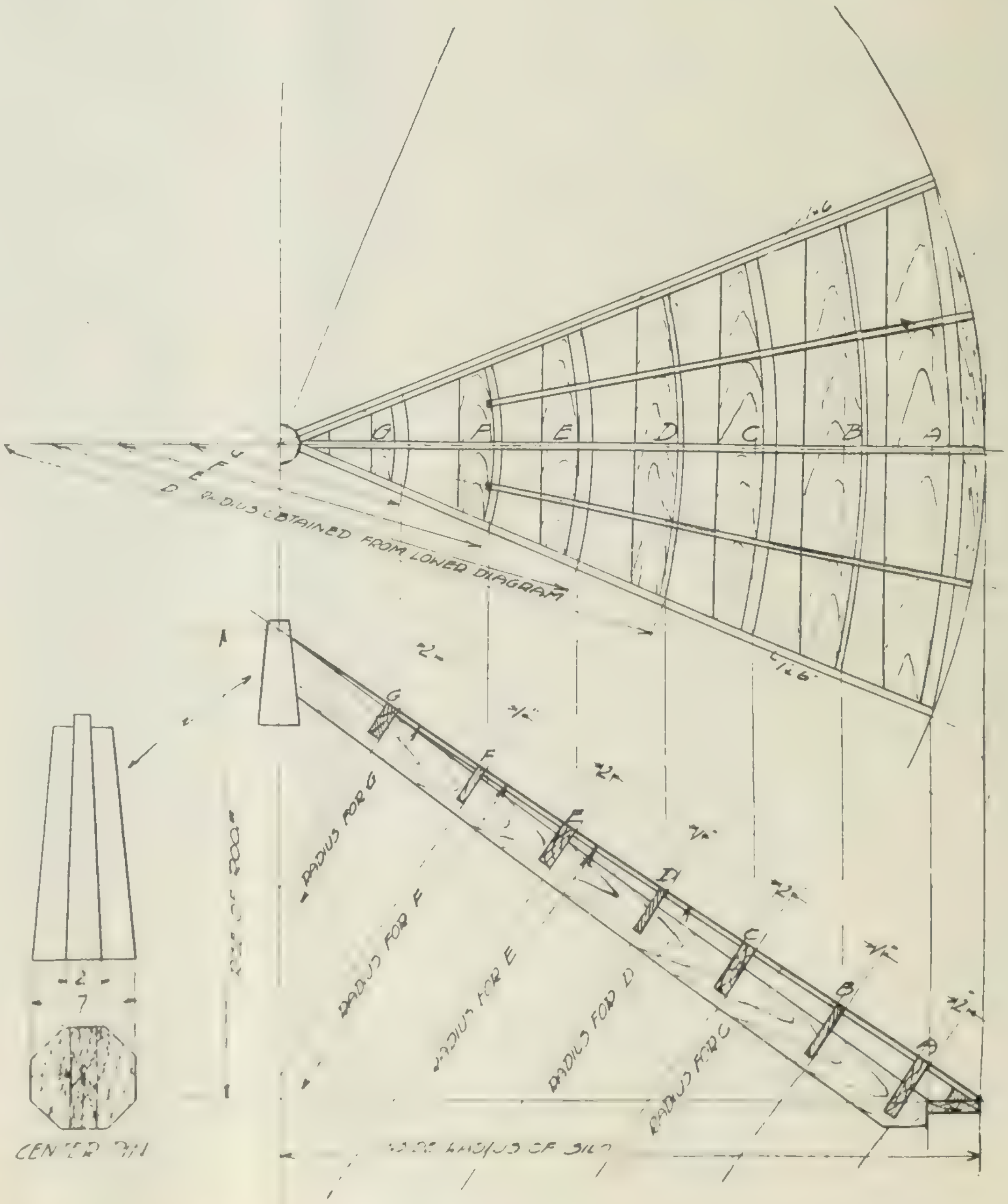

Fig. 18—Details of Sectional Roof Form

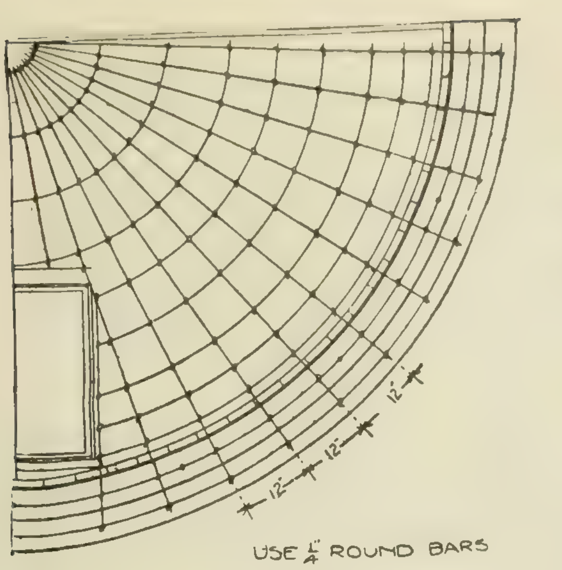

Fig. 19—Arrangement of Reinforcing Rods for Concrete Roof

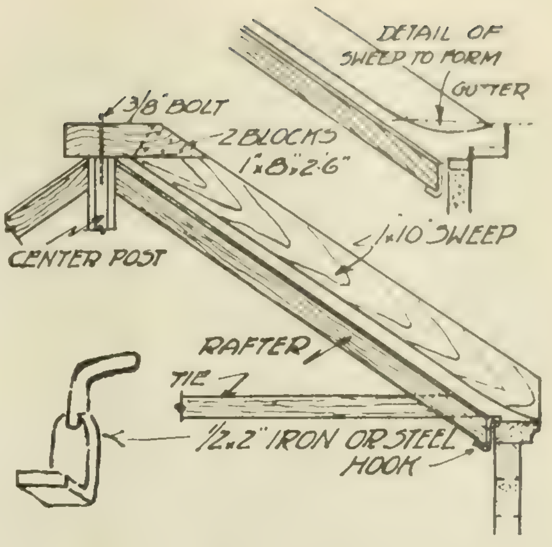

Fig. 20—Method of Using Sweep to Shape Roof

to about ⅕ by weight or approximately 5%.)

The concreting should start at the cornice after reinforcing is placed and the concrete should be stiff enough not to flow out of place.

Even thickness is secured by the use of a sweep as shown in Figs. 17 and 20.

If desired a gutter can be formed by properly shaping the sweep.

Dormer.—Most owners want a dormer in the silo roof for ventilation and for convenience in filling.

A stock form can be made in sections to be re-used as often as necessary. Local practice will determine the exact style, but the details in Fig. 21 will at least be suggestive.

The sides of the wall forms should be set up and scribed to the roof form section for final fit. Remember that concrete looks better and works better in curves than in sharp angles—try to get the habit of looking for the best way to do it in concrete—forget how the carpenter does it—he is using another material.

PRICES OF CONCRETE SILOS

Most silo contractors figure silos at a base price per ft. in height. The usual sizes are reported by various contractors about as follows: A 12-ft. diameter silo is worth about $6.50 per ft., exclusive of sand and gravel, water and cement. The farmer furnishes these materials, doing the hauling and boarding the help. The contractor furnishes labor and other materials to complete the silo. A 16-ft. silo is worth about the same price for labor alone. A 16-ft. silo is often contracted for at $12.00 per ft., contractor furnishing everything but hauling and board.

Other reports sent us quote prices as high as $16 for a 14-ft., $18 for 16-ft. and $20 per ft. for 18-ft. silo. These costs are contract prices and furnish everything complete and the silos erected at this price are usually in the best dairy sections of the middle states. The workmanship and finish are exceptionally good. These prices carry overhead, insurance and profit. Variations in cost of materials and labor account for a considerable variation in prices.

It is seldom possible to compete in price alone with the wood silo. The wood silo agent's price never includes excavation, foundation, erection, roof, chute, painting and guying, and by the time the farmer has paid all these items he has often learned that the price for the complete wood silo very closely approaches that of concrete.

The fact must not be lost sight of in meeting competition that the limit of the wood silo is about 35′ to 40′, and where two such silos are required a single concrete silo would usually be the cheaper.

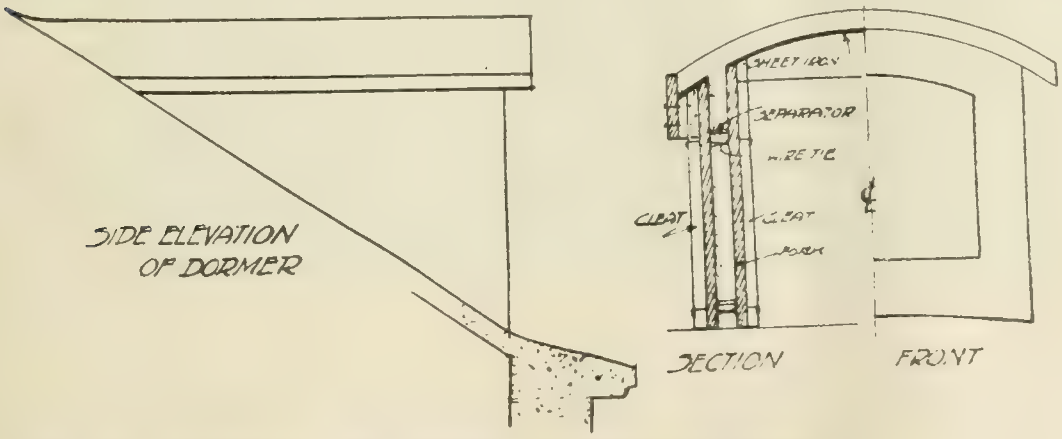

Fig. 21—Suggestion for Forms and Style of Dormer

Why is a Barrel the Unit of Cement Measure?

Here is something worth considering. It is hard to discard old terms for new, but it is frequently worth a little wrenching to uproot an old idea and make way for a new one. A reader writes:

The Standard Specifications for Portland cement, under General Conditions provide that:

> A bag of cement shall contain 94 lbs. of cement net. Each bbl. of Portland cement shall contain four bags.

The 400 pound barrel originated at the time when all of our Portland cement came from abroad and was actually packed in barrels. When we began to make Portland cement in this country we put it up in barrels weighing 400 pounds gross. Later, when, as a matter of package conservation, we began to put it up in sacks, we ascertained the net weight per barrel and divided it by four.

As will be seen from the specifications, the official unit of quantity is the bag or sack which must contain 94 pounds of cement. This being the Standard unit of quantity as well as the unit in which nearly all cement is actually handled, why not make our prices, contracts, invoices, bills of lading, etc., read sacks or bags instead of barrels? In other words, why not price cement in cloth 35 cts. per sack gross instead of $1.40 per bbl. gross, and in paper 27½ cts. per bag gross, instead of $1.10 per bbl. gross?

In tracing a quantity of cement from the time a quotation is made until the empty sack has been returned it will be seen that the figures are frequently converted from barrels to sacks, and sacks to barrels.

A price is made and accepted. The order calls for barrels but when it is sent to the mill, barrels are converted into sacks and sacks are loaded into the car. In making out the invoice, however, the sacks are converted into barrels but when the consignee receives the car he converts the barrels on the invoice to sacks to check out the contents of the car. When the dealer's customer buys 10 bbls. of cement his order is converted to sacks and 40 sacks are delivered but in invoicing the material the sacks are converted into barrels and the invoice calls for 10 bbls. The customer then changes this to sacks to make it correspond with the actual delivery.

When the sacks are emptied the word "barrel" seems to get out of our vocabulary and instead of calling "four empty sacks" "one empty barrel," the sacks are called by their right name.

Why should not prices, orders, contracts, invoices, bills of lading, etc., correspond with our goods? This change may seem quite formidable and it would involve a change in the habit of thought of some people, principally the manufacturers of cement, but against the inconvenience of a few hundred people, we will have the convenience of hundreds of thousands of engineers, architects, inspectors, dealers, contractors, bookkeepers, clerks, farmers, teamsters, etc.

Let some of these interested architects, engineers, contractors and others say what they think of the proposed change.

Flat Slab Floor of Unique Design at Cleveland Railway Company Car Shops

(CONTRIBUTED)

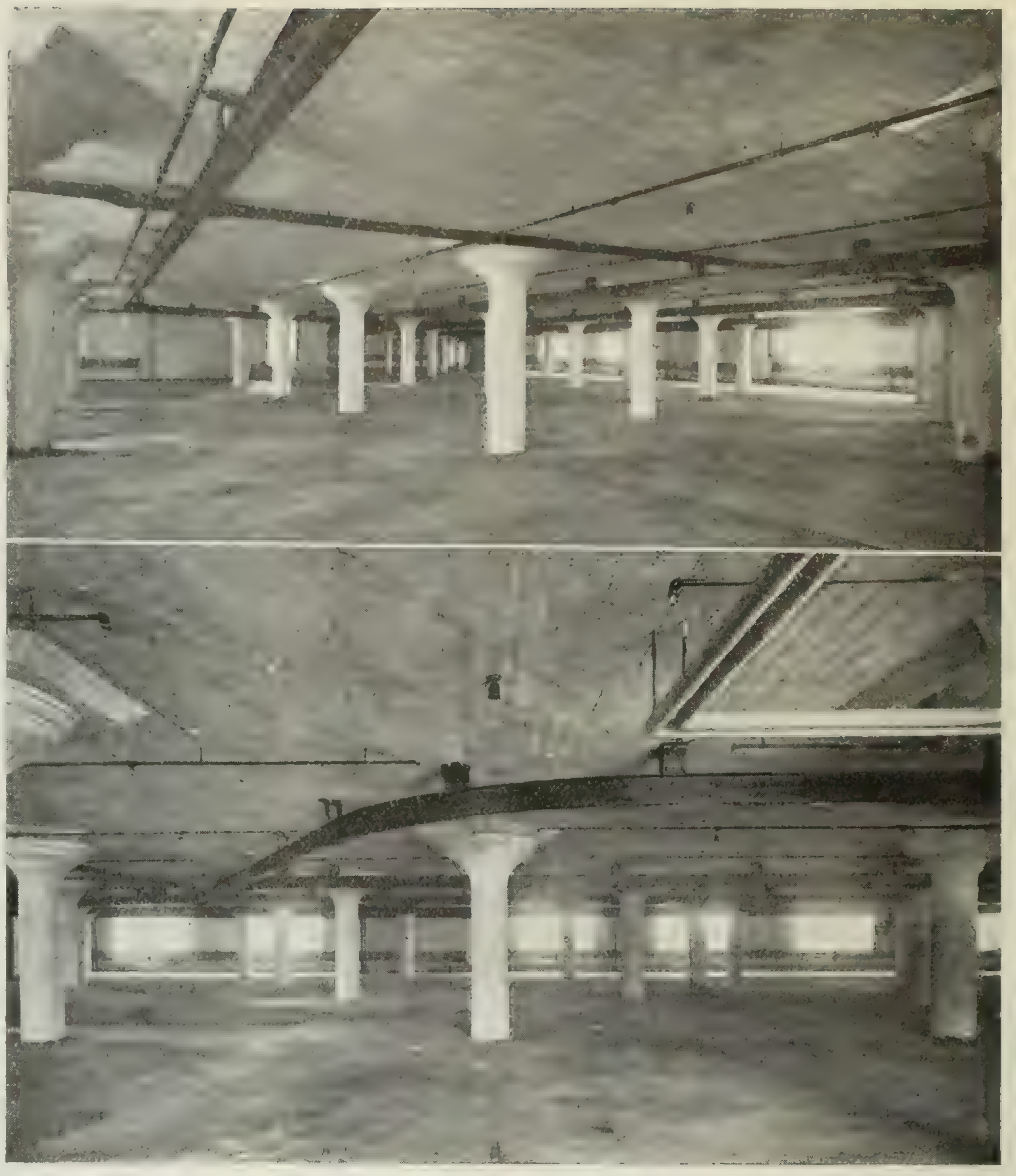

FIG. 2—VIEWS IN STOREHOUSE TAKEN NEARLY AT RIGHT ANGLES

Note open appearance

The Cleveland Ry. Co., Cleveland, has erected new shops covering an area of about five acres and costing more than $1,000,000.

One of the new features introduced in this group of buildings is the unique flat slab floor construction. This consists of an entirely new arrangement of columns and reinforcing, invented by David W. Morrow[1], whose firm was engaged by the railway on this work.

The Morrow flat slab has been used for the floor construction in three shop buildings, namely: the store building, 184′ x 120′; the armature room, 80′ x 50′; and the oil storage building, 57′ x 30′. It is also being used as a cover for four reinforced concrete fire protection reservoirs, the one located at these shops being 55′ x 32′ and 13′ deep.

COLUMN ARRANGEMENT

The prominent feature of this system is its arrangement of columns so that in adjacent rows they are staggered and occur at the apices of a series of equilateral triangles. The advantages of this grouping may be summarized as follows:

1. Equilateral triangle formation makes all spans equal.

2. The floor space carried by each band is the same. (See Fig. 1.) When uniformly loaded, the stresses are practically equal around the column head, due to the symmetry of construction.

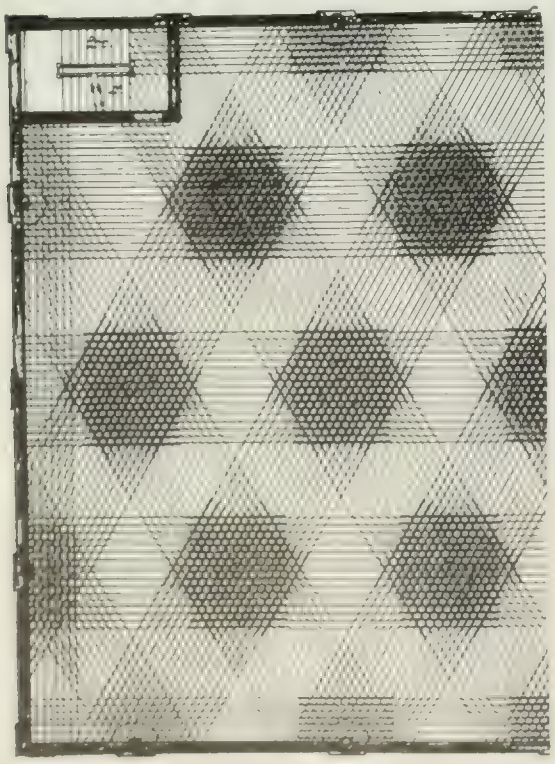

FIG. 1—TYPICAL FLOOR PLAN

Note equilateral column spacing and uniform span

3. This column arrangement eliminates sharp turns and facilitates the running of vehicles and the handling of material of unusual length on the floor. The aisles run in three general directions, and are all of the same width. Standing at any interior point on the floor, except directly between two columns, the aisles radiate in six directions, giving much open floor space.

4. Diagonal arrangement of aisles makes four or more full aisle views from any point on the floor, also giving an open effect, as is shown by Fig. 2.

5. Reinforcement is easily laid. All reinforcing rods in the interior panels are of the same length.

At Fig. 3 is shown a typical arrangement of bars at column and typical column design. The dimensions noted are those used on the store house of the Cleveland Ry. Co.

Fig. 4 shows diagramatically the arrangement of reinforcing and the exceptionally well equalized loading as indicated by the diamond-shaped spaces.

CONSTRUCTION DETAILS

In the Cleveland Ry. Co.'s store house, the decking consisted of 7/8-in. surfaced lumber, resting on 4-in. x 4-in. stringers, supported by 4-in. x 4-in. shores, spaced 4′ o. c. each

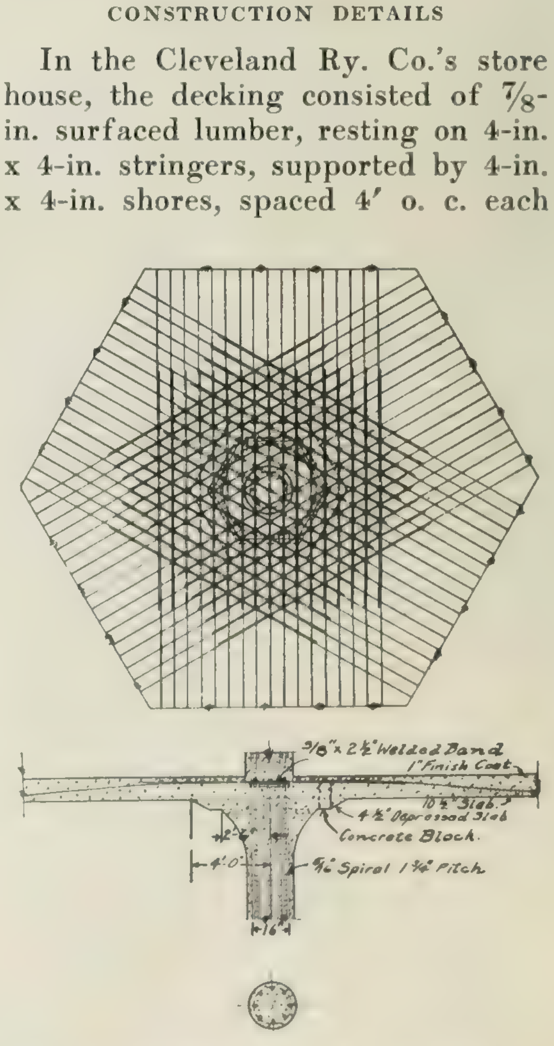

FIG. 3—TYPICAL COLUMN DESIGN AND ARRANGEMENT OF SLAB REINFORCING

way. Forms for the columns and flaring caps were made of galvanized sheet metal.

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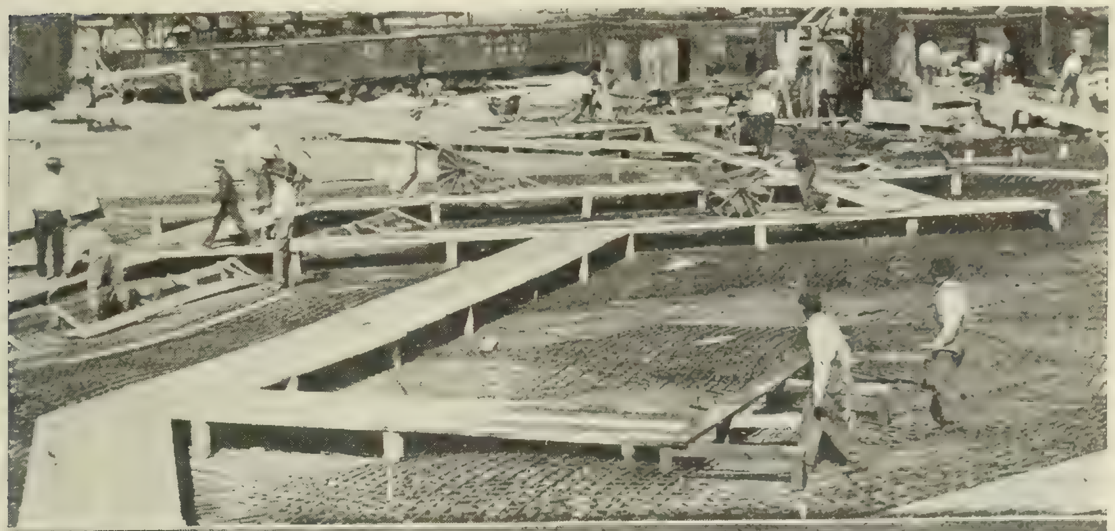
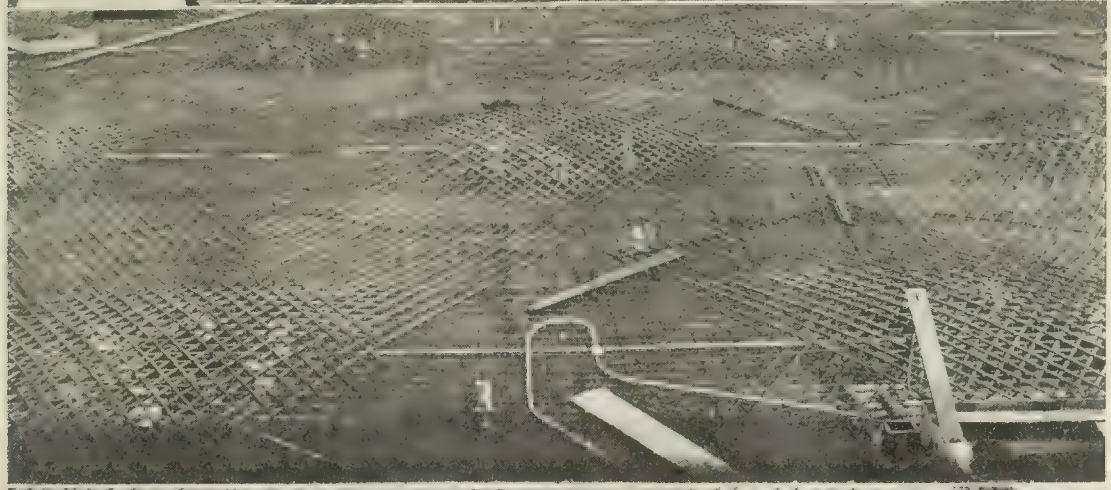
[1] Morrow & Cross, civil and arch. engrs., Cleveland

PLACING OF STEEL

In each band midway between columns was used a Securo spacer.[2] The steel over the column head was supported upon straight rods placed at right angles to each band, and resting on six pre-cast concrete block of the proper height to hold the steel in the bands at the top of the slab over the column heads and allow it to drop to the bottom of the slab midway between the columns. These supporting rods thus formed a hexagon (See Fig. 3). The reinforcing of the bands in one direction was laid, then successively the steel of the bands in the two other directions, forming three layers of rods over the column. When laying the steel in any band, the middle rod was laid first, extending over the center of the columns and held by the middle clamp of the spacer located midway between columns; the remaining rods were then laid parallel and held midway between the columns by the mechanical spacer. The rods in the other bands were laid in a similar manner. The reinforcing was then wired at the intersections along the line of the hexagonal figuhe formed by the outer rods of each band.





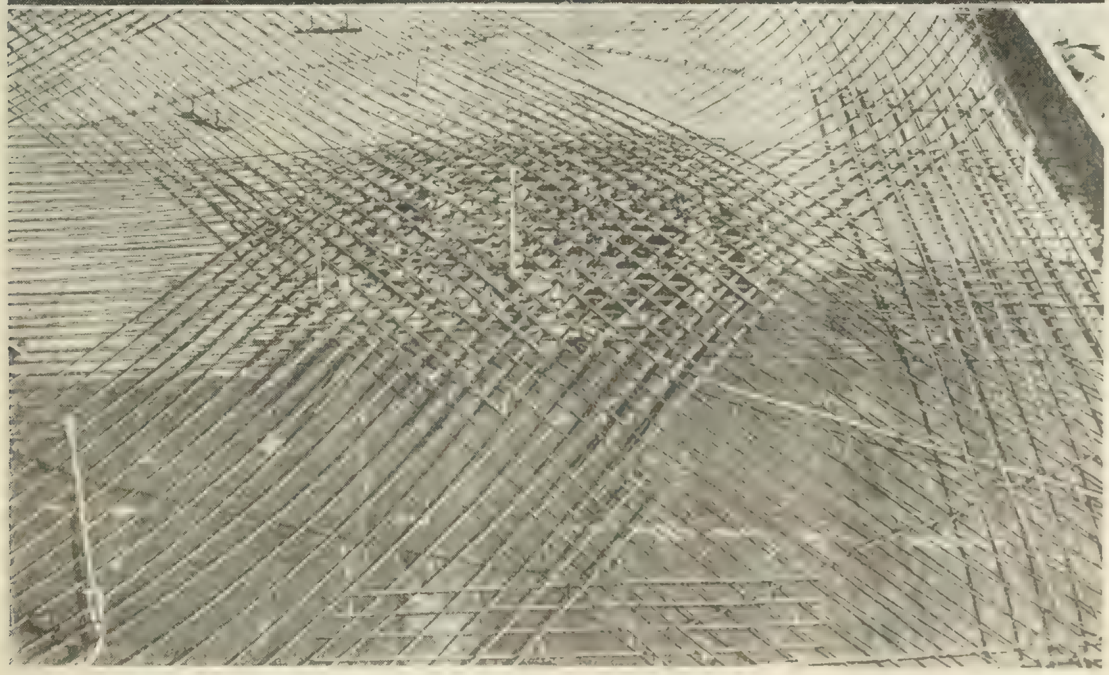


Fig. 5—Placing Concrete
Note arrangement of reinforcing makes displacement unlikely

Fig. 6—General View of Reinforcing

Fig. 7—Detail of Reinforcing Over Column

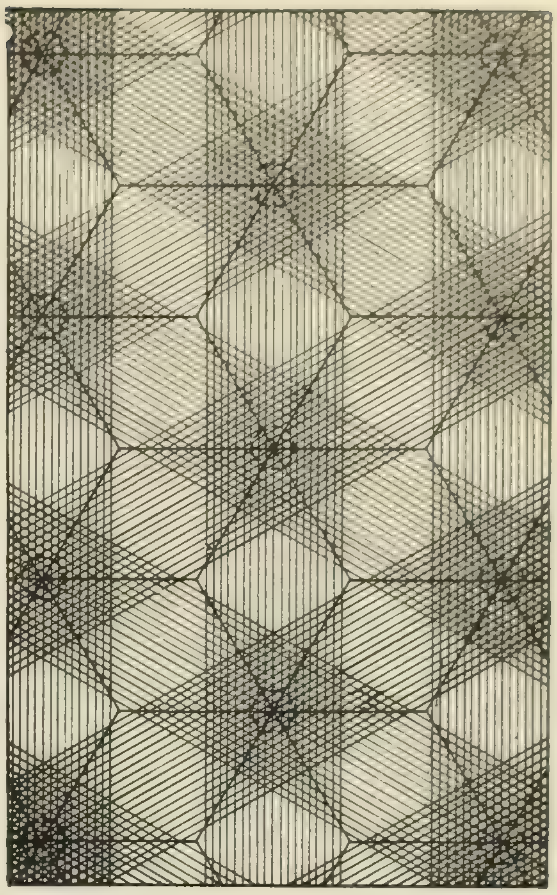


Fig. 4—Load Diagram

Note exceptional equalization of loading

PLACING CONCRETE

When practicable the columns were poured up to the point where they begin to flare, at least 12 hrs. before the slab. This did not delay the pouring of the slab, as enough columns were poured the day before and allowed to stand over night. The rods used in this particular floor were $\frac{1}{2}$-in. round, spaced 6" o. c., and no trouble whatever was experienced in pouring the concrete in the column cap through the steel over the head. The size of stone used was that passing through a 1-in. ring.

In stopping the pouring at the end of the day, the break was made in a zig-zag line at right angles to the bands at the middle of the span. No special means were used to anchor the rods along the wall beams, except, that in some cases a right-angled hook was made to assist the bond.

The arrangement of the steel and the method of placing concrete by means of carts on runways is clearly shown in Fig. 5. The statement is made by the contractor, The W. I. Thompson & Son Co., that the floor construction was made especially easy, owing to the reinforcement being all of one size and length, and no bending of rods being necessary. It was noted; too, that the triangular arrangement of the rods eliminated much of the tendency to slip out of place and called for a minimum of tying.

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[2] Wm. B. Hough Co., Chicago

New Equipment, Methods and Materials:

New Tools with Which the Industry Works

This magazine will not publish "reading notices," so-called, for the benefit of advertisers. These pages are edited for the Reader, as are all other pages in "Concrete." Manufacturers are constantly producing new and better methods and developing old methods, materials and machines. The progress of the concrete field is measured by the development of its tools. All developments along these lines are of real interest and importance to men who want to improve the quality of their work, decrease its cost, increase its quantity. This department is for just that kind of Editorial material. We, therefore, welcome detailed announcements which will be of practical value to Readers. Under no circumstances will this magazine publish any announcement simply because an advertiser asks it, nor refuse publication because a non-advertiser asks it. Material must carry information of real consequence to the reader. All material will be edited on that basis regardless of the source from which it comes.—THE EDITORS.

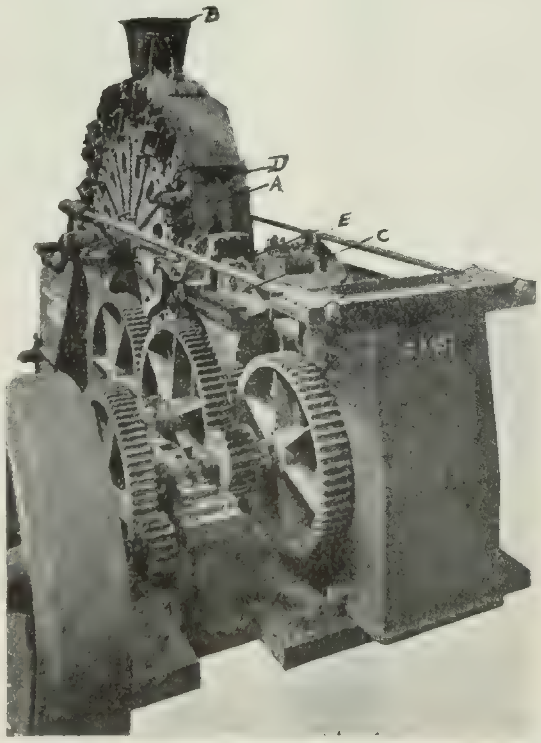
Fulcher Rotary Brick and Block Press

The machine shown in the accompanying illustration, although not yet entirely developed for commercial purposes, suggests interesting prospects in the field of concrete products manufacturer if it fulfills what what the early demonstration seems to promise.

It is the Fulcher[1] rotary pressure machine for making building brick and block. It is even prepared to turn out block made of cement and basalt rock, of a quality to stand up as a paving material.

The machine weighs about 40 tons and the mold carrier which is 9′ 6″ in diam. and 22″ wide weighs more than 12 tons.

Without going into any extensive description of all the mechanical details of this machine and the functions of the various parts, the main feature is the big wheel, or mold carrier at A in the accompanying illustration carrying numerous molds 8″ x 8″ x 20″. These are filled, as the wheel revolves, from the hopper at B, and compressed by the plunger at C. The opening of one of the molds is shown at D and the plunger, forced by a toggle construction, is shown entering another of the molds at E.



FULCHER ROTARY PRESS

The maximum size of product with the present mold carrier is 8″ x 8″ x 16″, allowing for a compression of 20% in the space which is as already noted, 20″ deep. Smaller products are made by inserting liners in the present molds or small brick are made by dividing the mold space.

The molds and plunger involve, of course, male and female dies. The manufacturers believe that the machine will show a capacity of 7,200 full size block per da. of 10 hrs. or 36,000 brick when proper adjustments have been made for producing the small units.

The manufacturers furnish a report of tests made by Robert W. Hunt & Co.[2] on products furnished by the makers of the Fulcher press, showing on an absorption test as low as from 1.7% to 2.2% and in compression from 4,098 lbs. to 4,352 lbs. The report is dated Mar. 3, this year.

An Improved Tying Tool

The tyer illustrated carries a new feature consisting of an adjustable collar by the use of which the correct number of twists can be given to tighten a tie of given length. With the improved Bates tyer[1] one length of tie can be used on several sizes of bars with good results.

BATES TYING TOOL

A Concrete Block Corncrib

The corncrib shown in the accompanying illustration is 18′ in diam., 24′ in height and is built with Anchor[2] ventilated corncrib block that

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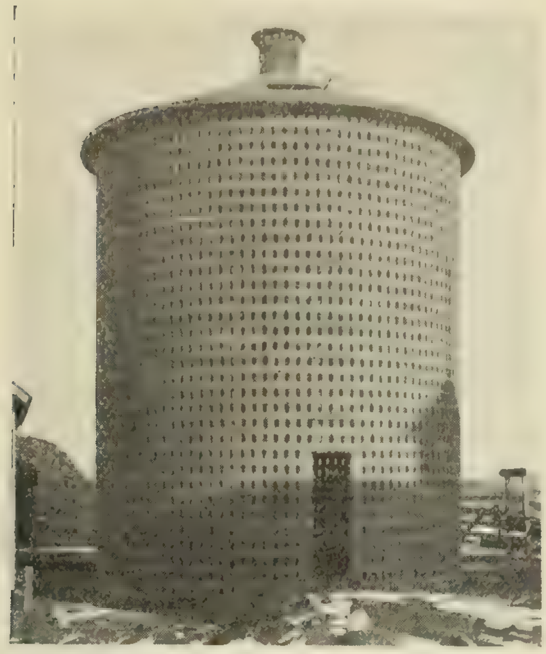
[1] Fulcher Concrete Block & Paving Co., Oakland, Cal.

[2] Testing Laboratories, Chicago

[1] Bates Valve Bag Co., Chicago

[2] Anchor Concrete Stone Co., Rock Rapids, Ia.



Concrete Block Corncrib

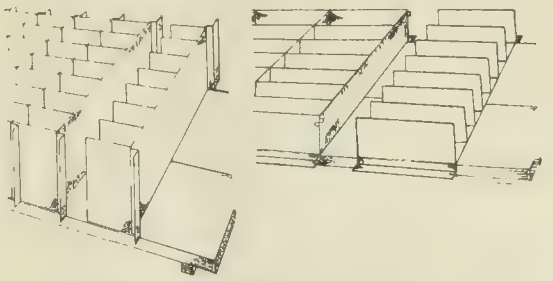
occupy a space in the wall 8″ in height and 24″ in length. Each block has three full holes and two half holes, about 2½″ wide and 4½″ in height with about ¼-in. slant on the front, allowing any moisture to drain outward instead of inward. The ventilated air space in the wall is 25%. Each corncrib block has a groove in the top similar to silo block, and in this groove is placed ¼-in. twisted reinforcing wire every 8″ in height. The corncrib has a concrete floor 4″ thick with a 2-in. slant from the center to the sides. It has a "drag" running directly through the corncrib, for an elevator chain used in removing the corn. The corncrib is filled through a man hole in the roof by means of a regular farm elevator of 40-ft. height; and will hold 2,500 bus.

The corncrib is equipped with center air chute 2′ x 2′, using the same block as for outer walls. This extends, square, to within 4′ of the center of the roof. Above this 24-in. tile are used. The shoulder of the tile is used to hold the end of the falsework to support the reinforced concrete roof.

Boards used to support the concrete or falsework are made from 1-in. lumber cut to fit the circle, one end being placed on this shoulder on the center of the air chute, and other end on the edge of the coping. On this falsework spacing strips 3′ apart at the bottom running to the centers are placed to hold the reinforcing wires. The strips have holders so the ¼-in. twisted reinforcing wires are held about 6″ apart, winding around the top of the crib like a spider's web. On this reinforcing is placed 3″ of slush concrete. After the concrete has hardened the loose boards are removed.

Molds for Wet Process Brick

Simple mold sections for use in making wet-process concrete brick,[1] plain or faced, are shown in the accompanying illustration. The molds are made of a fairly heavy and stiff spring steel, in sections for seven brick each. These are set up on plank platforms, over any convenient area, to be filled. For common brick the sections are set up on end, as shown at the left in the illustration, the sections interlocking by means of the projecting parts of the sections, as shown. For faced brick, the molds are set up as shown in the illustration at the right. They are filled to within about ¼″ of the top; the wet concrete is given time in which to stiffen and then the facing mixture is placed on top and struck off. In order to prevent sticking, molds are oiled before using. The manufacturer recommends a simple mixture of 1 qt. of axle grease to 1 gal. of gasoline, applied with a brush, if only a few molds are used, or dipped if used in quantities and permited to drain over the tank containing the mixture. Molds are to be used about 1 hr. after being oiled and the wet concrete is not to be puddled; instead, the platform should be jarred to insure density. If brick are to be made in very large quantities, molds can be mounted on cars, yet as 1,000 brick can be poured in the space provided by three 16-ft. platforms, 16¼″ wide, small outputs would not require cars. Due to the wet mixture, steam curing is not considered necessary. A warm but sheltered position only is recommended. Brick are released for piling and further curing after about 24 hrs., the brick being borne off in the mold sections, seven at a time, and released by springing the mold very slightly.

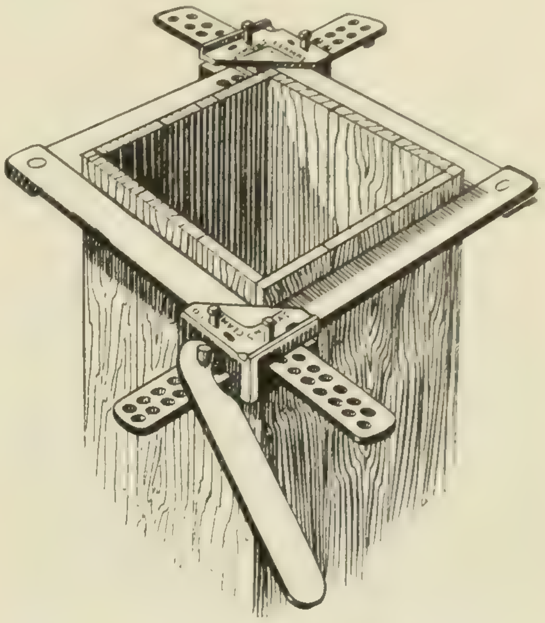


At Left, Molds Set Up for Common Brick; At Right, for Faced Brick

The Symons Column Clamp

An efficient and rapid method of clamping columns is a necessity to the builder of concrete structures. The illustration shows the Symons column clamp[1] and renders unnecessary extended description.

The clamp is adjustable to the range of sizes usually needed and is very simple in operation. The illustration shows the method of clamping by means of a very powerful eccentric lever.

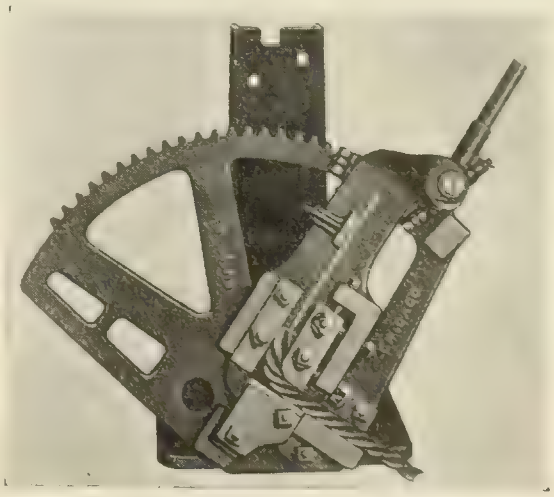


The Symons Column Clamp

A Hand-Power Bar Bender with Ratchet Attachment

Within the last few years considerable progress has been made by manufactures in providing machines for bending cold reinforcing bars readily and adaptively into every conceivable form and shape required in reinforced concrete construction. The accompanying illustration shows one of several styles and sizes of Wallace bar benders.[2] This apparatus, known as Nos. 4 and 5 bar benders, is a powerful machine, capable of being operated by one man and bending reinforcing bars up to 1¼″ in size, without heating the bars.

The machine has an auxiliary ratchet lever, which operates a pinion against a series of teeth in the frame, at a large ratio, thus exerting



Wallace Bar Bender With Ratchet Attachments considerable power. The ratchet pawl may be thrown out of engagement and the machine operated with the regular lever, making it suitable for bending light stock cold or heated stock at a rapid rate. The machine will also bend hot flat stock 4″ wide by ½″ thick, or its equivalent, when fitted with special high dies. Low dies are preferable for bending rounds and squares. All dies have tool-steel face plates and can be easily adjusted by means of set screws to suit the thickness of stock to be bent.

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[1] Merrill Moore, Creston, Ia.

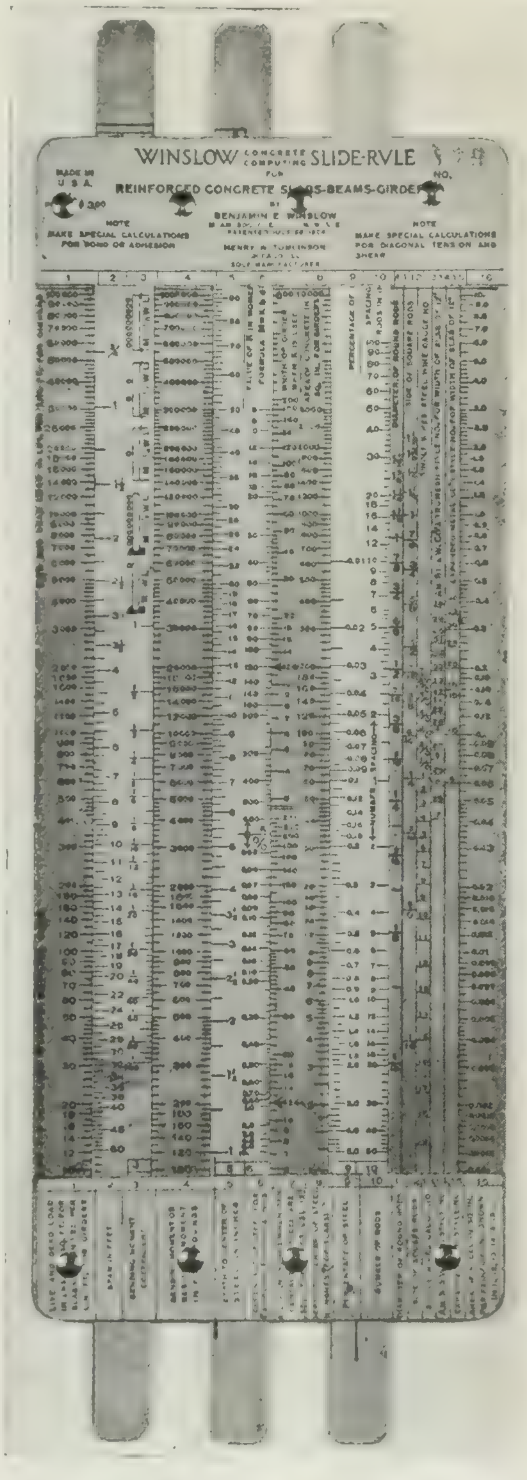
[1] Symons Clamp Co., Chicago

[2] Wallace Supplies Mfg. Co., 414 Orleans St., Chicago

The handle of the machine is fitted with anti-friction rollers and a special dog to prevent back-lash. The ratchet attachment can be removed when it is desired to bend light stock quickly, which can be done by using the regular handle or lever, as shown. The illustration shows a top view of the machine after being removed from the cast iron supporting stand and shows a square twisted bar bent to a right angle.

A Strength Computing Slide Rule for Reinforced Concrete Beams and Slabs

The accompanying illustration shows the new Winslow[1] concrete computing slide rule for quickly calculating reinforced concrete slabs, for any load, span, thickness, percentage of steel, size and spacing of reinforcement, etc. It may also be used for computing reinforced concrete beams. The rule covers spans from 6″ to 70′; loads from 10 lbs. to 100,000 lbs.; bending moments from 100 ft.-lbs. to 1,000,000 ft.-lbs.; various kinds of reinforcement, including rods, triangular mesh, expanded metal, etc.; percentages of reinforcement ranging from 0.01% to 5%; and various concrete and steel stresses in common use. The device is 4″ x 10″ x $\frac{3}{16}$″ thick; it is made of hard fiber, waterproofed, and weighs about 4 ozs. The set of instructions which accompanies the rule explains fully its scope and application.

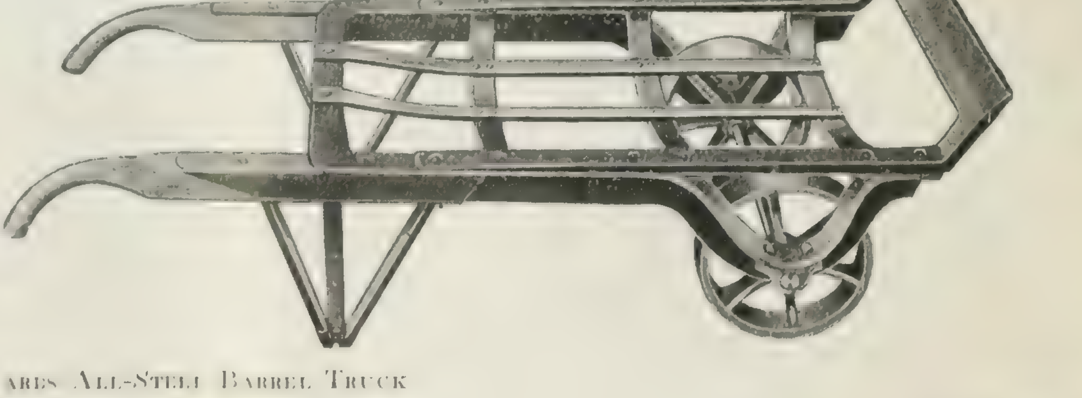

WINSLOW CONCRETE COMPUTING SLIDE-RVLE
MADE IN U.S.A.
FOR
NO.
REINFORCED CONCRETE SLABS-BEAMS-GIRDERS
BY
BENJAMIN E. WINSLOW
NOTE
MAKE SPECIAL CALCULATIONS FOR BOND OR ADHESION
HENRY W. TOMLINSON
SOLE MANUFACTURER
NOTE
MAKE SPECIAL CALCULATIONS FOR DIAGONAL TENSION AND SHEAR

Winslow's Concrete Computing Slide Rule

A New Line of Warehouse Trucks

Material men and others having warehouse trucking problems will be interested in a new line of all-steel trucks[1] built for the hard service demanded of this class of equipment. One form very popular for those handling lime and other barreled materials is shown in the cut and is representative of this line, which comprise special shapes for all uses.

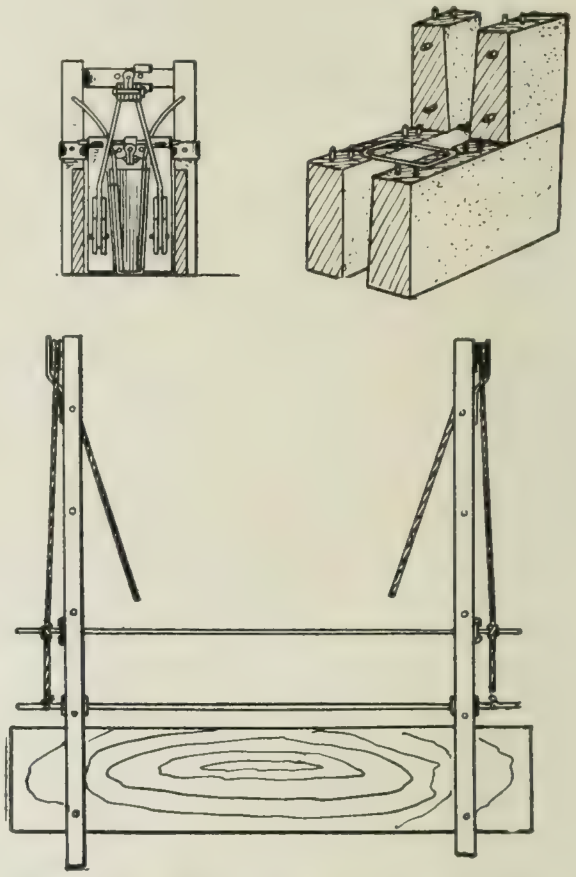
A glance at the frame construction showing a continuous piece of angle-iron forming rails, wheel bearings and front cross-bar is evidence of the sturdy nature of this equipment.



Edwards All-Steel Barrel Truck

Molds for Insulated Concrete Walls

Several types of molds have been placed on the market for constructing a double concrete wall having an intermediate air space between the members of the wall. The accompanying illustrations show an adjustable mold[1] for walls of different thicknesses and provided with means whereby the mold may be raised after each molding operation.



The Frost Mold for Hollow Concrete Wall Construction

The operation of the molds may be briefly described as follows: When the desired number of sections of the molds have been connected together to form the wall, the concrete is poured in between the core and the mold members and after it has set the mold members are moved outwardly a short distance and are then raised by means of the ropes or cables, for the next tier, as will be readily understood from the illustrations.

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[1] The device was invented by Benjamin E. Winslow; its mechanical construction was designed, and the rule is manufactured, by Henry W. Tomlinson, 62 East Van Buren St., Chicago.

[1] The Edwards Mfg. Co., Cincinnati

[1] Invented by H. T. Frost, Mitchell, S. Dak.

A Furring Post for Metal Lath

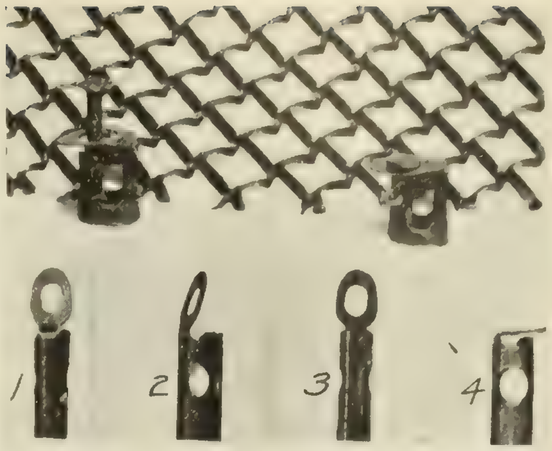
There has recently been invented a device known as Furr-Easy Post.[1] This device is made from metal, formed as shown in the illustration, in three lengths to suit the requirements of the user, and in its application is inserted through the openings of the metal or wire lath, the lip is turned down over the strand, and a nail driven through the hole in the flap, thereby producing a positive fastening, holding the lath rigidly in place, and giving a smooth and even surface. The post is open at the back and sides admitting plaster to fill the interior for its protection.

Fig. 1 shows front. Fig. 2 shows side. Fig. 3 shows back of the device with the lip or flap turned up in which shape posts are marketed, and Fig. 4 shows the flap down as it will appear when in place.

The use of this furring post obviates furring strips. The entire lath is back plastered, thoroughly covered and embedded with equal thickness in an unbroken surface throughout, therefore acting in unison during action of expansion and contraction. The contact has thus been brought to a minimum and there are no hands of weakness to develop cracks.

It is said that lath can be securely fastened, stiff and rigid, for application of mortar with twelve posts per square yard.

The upper part of the illustration shows piece of metal lath fastened with the furring post.



THE FURR-EASY POST

Current Prices — Concrete Materials □

Portland Cement—The cement market is not up to normal, but prices have in general been increased during the past month. In certain quarters the demand is increasing slightly. Prices given are f. o. b. cars at points named, including cloth sacks, for which, in general, 40 cts. per bbl. (4 sacks) is refunded on return in good condition. Prices per bbl. (including 4 cloth sacks) are as follows: Boston, $1.46; New York, $1.22; Chicago, $1.51; Pittsburgh, $1.46; New Orleans, $1.63, on dock; Memphis, $1.80; Cleveland, $1.64; Detroit, $1.60; Indianapolis, $1.64; Columbus, $1.64; Cincinnati, $1.59; Toledo, $1.64; St. Louis, $1.50; Milwaukee, $1.63 to $1.68; Minneapolis, and St. Paul, $1.67; Duluth, $1.82; Peoria, $1.59; Cedar Rapids, $1.70; Davenport, $1.60; Kansas City, $1.53; Omaha, $1.53; Spokane, $1.75; Seattle, $2.40; Portland, Ore., $2.40; Tacoma, $2.40.

Crushed Stone—1½-in. stone, prices per cu. yd., f.o.b. cars in carload lots, unless otherwise specified. Boston, 80 cts. per ton at the quarry; New York, 95 cts. in full cargo lots at the docks; Chicago, $1.15; Spokane, $1.00; Portland, Ore., $1.15; Seattle, $1.50.

Gravel—Prices given are per cu. yd. f.o.b. cars in carload lots unless otherwise noted. New York, 80 cts. in full cargo lots at docks; Chicago, $1.15; Spokane, $1.00; Portland, Ore., 85 cts.; Seattle, 75 cts.; Tacoma, 75 cts.

Sand—Prices are per cu. yd. f.o.b cars in carload lots unless otherwise indicated. New York, 50 cts., full cargo lots at docks; Chicago, $1.15; Spokane, 75 cts.; Seattle, 75 cts.; Portland, Ore., 85 cts.; Tacoma, 75 cts.

Reinforcing Bars—On account of the great demand for large size bars for foreign orders for shells, mill orders are being taken for delivery in five to six weeks. This lengthening of delivery together with increasing prices has forced numerous large buyers to close contracts at once, on which it was evident special prices were desired. The general tendency of the market is that August deliveries will be made on a basis of $1.30 per cwt., Pittsburgh, with prevailing extras for bars under ¾" or base. The following are quotations on base bars per 100 lbs., for mill shipments from other points, f. o. b. cars: New York, $1.469; Philadelphia, $1.459; Chicago, $1.489; Spokane, $2.05; Portland, Ore., $1.85; Seattle, $1.85; Tacoma, $1.85; San Francisco, $1.70.

Shipments from stock are being made at the following prices per cwt. f.o.b. New York, $1.90; Philadelphia, $1.80; Cincinnati, $1.80; Cleveland, $1.80; St. Louis, $1.70; Chicago, $1.70; St. Paul, $1.70; Spokane, $2.35; Portland, Ore., $2.15; Tacoma, $2.15; Seattle, $2.15; San Francisco, $1.70.

Metal Clips for Supporting Bars—$4.50 to $6.50 per 1,000, depending on size.

For the majority of the prices given we are indebted to the Universal Portland Cement Co., Sandusky Portland Cement Co., Concrete Steel Co., American Sand & Gravel Co., Chicago, and F. T. Crowe & Co., Seattle, Portland, Spokane and Tacoma.

Reinforcing bars for mill shipments are in general sold on a Pittsburgh basis; this is, at the Pittsburgh quotation plus the freight to the point in question, and with the following list of freight rates on finished material and the Pittsburgh quotation given, the price of bars at any of the points listed can be readily computed.

From Pittsburgh, carloads, per 100 lbs. to:

Albany	16.9	cts.
New York	16.9	“
Philadelphia	15.9	“
Baltimore	15.4	“
Boston	18.9	“
Buffalo	11.6	“
Cleveland	10.5	“
Birmingham	45	“
Cincinnati	15.8	“
Chicago	18.9	“
Denver	68.6	“
St. Louis	23.6	“
New Orleans	30	“
Minneapolis	32.9	“
Indianapolis	17.9	“
Kansas City	43.6	“
Omaha	43.6	“
Pacific Coast Points (Rail)	80	“

Now that the Panama Canal has been opened to traffic ocean freight rates on reinforcing bars to Pacific Coast points have been established which materially lower the delivered cost of bars from the east. The rates per 100 lbs. to Pacific Coast points for large lots are: From Pittsburgh, 61.9 cts.; Chicago, 76.5 cts.; Youngstown, 63.9 cts.; New York, 45 cts.; Bethlehem, 52.9 cts.

Trade Publications □

C. H. & E. Contractors' Equipment, Catalog No. 8—C. H. & E. Mfg. Co., Milwaukee, paper, 9" x 6", 44 pp., illust. This is a well printed publication, in colors, showing the C. H. & E. line of wood-working tools in an especially attractive manner. The line includes power saws, pumping equipment, hoists, elevators and mortar mixers. It shows also a line of concrete chutes and gasoline engines.

The C. H. & E. No. 6 Portable Saw Rig—C. H. & E. Mfg. Co., Milwaukee, paper, 9" x 6", 8 pp., illust. This bulletin features a combination saw rig and is of interest to every contractor desiring a strictly up-to-the-minute piece of equipment for doing all kinds of wood work on the job.

Chain Belt Concrete Mixers—Chain Belt Co., Milwaukee, paper, 9½" x 7½", 64 pp., illust. This exceptionally well printed catalog shows in a most convincing way the Chain Belt line of concrete mixers. It is profusely illustrated and the cuts are large and clear. It also describes equipment for hoisting and chuting concrete.

The Hoosier Silo Roof—Sheet Metal Specialty Co., Goshen, Ind., paper, 9" x 6" 32 pp., illust. This catalog describes in great detail the Hoosier silo roof. A strong feature of this roof is that it opens and forms an additional section of silo during the filling and is closed after the silage has settled, enabling the full capacity of the silo to be used. This roof is adapted to all types of concrete silos.

Plants for Washing Sand and Gravel—The Raymond W. Dull Co., Chicago. Paper, 10" x 6¾", 80 pp., illust. This book is exceptionally well printed and illustrated. It makes clear to the reader the construction of Dull sand and gravel plant equipment, also illustrates and describes a number of plants which this company has designed and equipped. The book will prove valuable to producers and prospective producers of concrete aggregate.

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[1] The Wagner Behm Co., Chicago.

Koehring Mixer—Koehring Mach. Co., Milwaukee, Wis. Paper, 7½" x 10½"; 96 pp., illust. The new catalog is in many ways of value to the concrete contractor, outside of its information and description of Koehring mixers. The catalog itself is of unusual size, handsomely printed, with cover in four colors, and inside pages in three colors. It illustrates and describes the entire Koehring line of side loaders, pavers and hot mixers. There are many reproductions of photographs showing Koehring mixers "on the job." There are detailed descriptions of mixer construction, special automatic features, including the batchmeter, which signals the readiness of a either side of the mixer, increased leverage of discharge lever, securing easier operation. It also shows new automatic knockout and brake on loading skip by which the loading skip automatically stops at charging position, and stays there until released. Another improvement described is the power-driven platform-controlled distributing spout, by which the distributing spout is lengthened or shortened, or swung to any position by the operator on the control platform, with the same flexibility as the boom and bucket system, the spout maintaining a uniform distance from the ground at every point of delivery.

Efficiency and Service—Electric Welding Co., Pittsburgh, paper, 9" x 6", 8 pp., illust. This well illustrated pamphlet points out the advantages of the continuous spacing bar, consisting of a steel section equal to a ⅜-in. rod having fingers punched out of the top for holding reinforcing bars in place and on the bottom electrically welded chairs for supporting the steel. This form of spacer acts as a transverse reinforcing bar and it is pointed out that it can be used to advantage in a vertical position.

Metal Lath Hand Book—Associated Metal Lath Manufacturers, Youngstown, Ohio, cloth, 9¼" x 6¼", 128 pp., illust. $1.00 postpaid.

This is a hand book on Metal Lath and its uses. The limitations of wood lath as a vehicle for carrying plaster opened the way for a product that will not absorb moisture, and that is not combustible.

This book is designed to place concisely before architects and contractors the best methods of using metal lath; also illustrations and descriptions of the various kinds, and observations by the best authorities on construction affected by its use.

There will be found a condensed record of various scientific experiments, particularly in the way of fire tests which have been made to determine fundamental data affecting the use of metal lath.

Bonanza Data Sheets—American Cement Tile Mfg. Co., Pittsburgh, paper, 8¼" x 5½", 36 pp., illust. This pamphlet deals with the details of roofing tile manufactured by this company. The entire booklet is given over to working details, showing the exact method of framing to be used under all conditions, including details for cornices, monitors and sawtooth roofs. It is conclusive evidence that the details of this construction have been worked out in an exceptionally thorough manner.

E-Cod Fabric for Concrete Encased Buildings—E. D. Coddington Mfg. Co., North Milwaukee, Wis., paper, 8½" x 5¼", 32 pp., illust. This publication describes the application of E-Cod fabric to all forms of construction. Full, detailed directions are given for the application of the material and valuable information is given on the proper mixture and application of stucco. The book is well worthy of notice from its value to the builder as a source of information on the subject of stucco, aside from its purpose: to place a new structural material before the builders.

G-A Gasoline Diaphragm Pumper No. 16. Gray-Aldrich Co., Inc., Boston, paper, 11" x 8", 4 pp., illust. This folder describes a convenient pumping outfit for contractors' use. The gasoline engine is mounted on a substantial truck with one or two diaphragm pumps. Of special interest is the fact that equipment can be purchased with one pump and so arranged that the second pump can be added at any time without making serious changes in the first equipment.

Wagon and Truck Loaders—Link-Belt Co., Chicago. Paper, 9¼" x 6", 48 pp., illust. This catalog describes the Link-Belt line of wagon and truck loaders. It not only describes the equipment but illustrates it in actual use under varied conditions.

Simple Forms for Concrete—Vulcanite Portland Cement Co., N. Y. C. Paper, 6¼" x 3½", 24 pp., illust. This little pamphlet is issued to make plain to the beginner just how simple it is to erect forms for simple structures. It details the method of erecting walls, hot beds, chimneys and such other structures as are continually being built. It is a thoroughly practical little pamphlet and is worth many times the postcard that brings it.

Toch's Cement Filler and Cement Floor Paint — Toch Bros., N. Y. C. Paper, 6" x 3¼", 32 pp., illust. This little booklet is a convincing argument for the value of the concrete coatings which are described, as it shows instances of their use on some of the largest buildings in the country. A color card is included.

Concrete Reinforcement—Canada Wire & Iron Goods Co., Hamilton, Ont. Paper, 9" x 6", 24 pp., illust. This booklet describes wire reinforcing fabric. In addition to the fabric, it describes a number of special forms for reinforcing beams and girders. A considerable number of useful tables on the design of slabs is given, together with charts showing graphically the design of slabs for various spans and loadings. The use of wire fabric in sewers is also described.

Portable Crushing Plants—Smith Engineering Works, Milwaukee, Wis. Paper, 9" x 6", 24 pp., illust. Printed and illustrated in a way to show attractively the Telsmith portable crushing plants, and gravel screens and in a manner that will enable one to decide on their value for his work. The portable crushing plant is undergoing remarkable development and this pamphlet should prove valuable to any contractor facing aggregate problems.

Saginaw Silo Roofs and Chutes—The McClure Co., Saginaw, Mich. Paper, 6¼" x 3¼", 2-page folder, illust. This catalog describes a new departure in silo roofs, an asbestos-steel combination that seems to have some valuable features, and also describes a metal chute which can be attached to any silo.

Buckeye Silo Roofs—B. L. Bevington Machy. Co., Chicago, Ill. Paper, 9¼" x 6¼", 6-page folder, illust. This folder describes a form of steel silo roof which is easily applied to any concrete silo, and also describes the Buckeye silo chute and other silo hardware.

Smooth-On Iron Cement No. 7 — Smooth-On Mfg. Co., Jersey City, N. J. Paper, 9" x 6", 4-page folder, illust. This attractive folder sets forth the merits of Smooth-On Cement No. 7, a material for waterproofing concrete structures. The folder indicates that this material has merits that should recommend it to anyone facing waterproofing problems.

The Standard Concrete Mixer — The Standard Scale & Supply Co., Chicago. Paper, 9" x 6", 40 pp., illust. This publication illustrates and describes The Standard line of concrete mixers. The publishers have succeeded in showing their equipment in a clear and attractive manner, and it is interesting to note that they list several types of mixers that are of interest to those having specialized mixing problems.

Lansing Concrete Working Machinery Catalogue No. 12C—Lansing-Co., Lansing, Mich. Paper, 11¼" x 8¾", 36 pp., illust. In this catalog the Lansing-Company has succeeded in producing a publication more than ordinarily attractive. It shows, in a clear and convincing manner, the Lansing line of mixers and contractors' equipment.

The Addy Spacer for Reinforcing Bars —Lewis N. Lukens, Philadelphia, Pa. Paper, 6¼" x 3¾", 6-page folder, illust. This folder describes and illustrates the use of the Addy slab bar spacer and supporter, a specialty which seems to have a wide field of usefulness.

Weber Chimneys, 1915 — The Weber Chimney Co., Chicago, Ill. Paper, 9" x 5", 48 pp., illust. Splendidly printed, profusely illustrated treatise on concrete chimneys. Pictures of many completed chimneys together with their details of design and construction make this publication valuable to the manufacturer contemplating chimney construction.

Expanded Metal Lath — The Berger Mfg. Co., Canton, Ohio. Paper, 3½" x 6", 36 pp., illust. This is a condensed handbook on Berger metal lath and allied products. A new feature is the metal base screed. Standard plastering specifications are included.

Practical construction details are discussed, involving the various uses of metal lath, including elevators, stair shafts, ducts, etc., also beam and girder protection.

Suspended ceilings are treated in detail, with working drawings. The use of metal lath and plaster in moving picture booths, and notes on acoustics are of timely interest.

Plastering both exterior and interior is treated and specifications given.

The book also illustrates and describes in a concise manner the various forms of metal lath on the market, making available in compact form very complete information on this subject.

Automatic Weighing Machine—Automatic Weighing Mach. Co., Newark, N. J., paper, 9¾" x 7", 64 pp., illust. This is a well printed, looseleaf catalog containing descriptions of automatic scales for all kinds of material.

Concrete

Cement Age

Vol. 7 *Detroit, September, 1915* *No. 3*

Experience—An Expensive School

MR. Ames's article in this issue dealing with bridge failures stands as a danger signal to those responsible for concrete construction.

There is no evidence of fraudulent intent in this work and the contractors are said to be willing to replace the work, though it must be a hardship to them; the whole situation seems to show that those in charge did not sufficiently realize the need of care in selecting aggregate and placing concrete.

Heavy expenditure of time and money is not needed to become familiar with the essentials of good concrete; it seems that the time must be near when failures resulting from violation of first principles will cease.

The Chute and Tower

ONLY a short time ago a concrete job using a tower and spouting equipment was a sight to attract the attention of the public as a curiosity and the builder or engineer looked upon it as a unique method to be thoroughly tested before receiving his full approval. The last two years have seen a remarkable development of this economical and flexible method of handling concrete and even the comparatively small job finds the tower and chute practical.

The one objection to its use is the tendency, in order to secure an easy flow, to use too much water, causing a dangerous separation of the concrete. This is a very real danger against which one must always be on guard. The flow of concrete depends not only on its fluidity secured by excess water, but also upon its plasticity, which is an entirely different property.

Plasticity depends upon several causes, the proper grading of materials and very thorough mixing being most important. Concrete holding only such an amount of water as will make separation impossible will flow if given extra mixing.

Plasticity, secured by thorough mixing, causes an easy flow of concrete, helps it to work easily and thoroughly into place and around reinforcing, and insures a greater density and strength than with less thorough mixing.

A small amount of hydrated lime in the mix aids greatly in securing the easy flow required and is a valuable ally in obtaining dense and waterproof concrete.

Building Construction and the War

MUCH has been told of the fearful destruction of property in the war zone. Current illustrations show the devastation caused by artillery and other agencies of war on the fine old buildings of Belgium and northern France.

The thought suggested by these pictures is not so much wonder at the destruction as at the fact that the damage is not far greater.

Imagine the results of bombardment and invasions on American cities. In the war zone in many cases where a town was deliberately destroyed the individual buildings had to be fired. There was not enough exposed inflamable material to spread the fire even where it was encouraged rather than fought.

Without expecting that the terror of war will reach this land, it is easy to forsee the fate under bombardment of our cities with our firefighting forces out of commission.

There is at hand the best structural material ever given to man for his use. There are efficient means of using it. The one great hindrance is lack of knowledge. This applies to owner, architect, builder and workman.

A Job of Work

THERE are two viewpoints for a man doing a job of work. He will invariably choose one viewpoint or the other. Upon his choice will depend in a large measure the character of the work done and his own frame of mind with respect to all his work. The choice of one viewpoint or the other becomes habitual. In this habit the very character of the man himself is lost or won.

One viewpoint is epitomized in the idea: *Get the job done.* The other viewpoint is more difficult of definition, but it is concerned with, as the matter of major importance: *Doing the job.*

The man who is concerned chiefly with getting the job done is a time-server, a menial; his labor lacks dignity.

If the most important thing about a job is to get it done, then the job is not worth doing—because the only wages to be got out of it are those signified in the pay-check. Somebody else should do the job, for two reasons; because he could put more *into* the job in the way of interest, loyalty and character and because he could by these same measures be better paid for what he does. One man gets paid for hours and materials—for those are all he puts into the work; another man is rewarded in the satisfaction of painstaking performance because he has put something of himself into the task. If the work itself is not the most important thing, the most engrossing thing, about a job while that job is in progress, then the man is on the wrong job, because neither he nor the man who is paying him is getting all that should go with any work that is worth the effort that it requires.

Getting Nearer to Standard Practice

BUILDING codes are occupying a constantly more important place in engineering and contracting literature. The increased use of concrete construction in all its forms has made the specifications governing the use of this material a matter of much discussion and lively controversy between the advocates of concrete and the advocates of other materials which concrete is to a considerable extent replacing. A great many of the concrete men have felt that city building codes have been unnecessarily severe in the resistances required of concrete and in the limitations as regards height of construction allowed, which are imposed.

For these reasons the building code which is recommended by the National Board of Fire Underwriters, New York, is of special interest to all engineers and contractors. The Board has a reputation for natural conservatism, owing to the position which it occupies as an organization to minimize the fire risk, and for this reason it is gratifying to note that while the requirements for concrete are high, they are not unfairly so and that the specifications laid down for the use of concrete are along the lines of standard modern practice. The work of the Am. Soc. for Test. Mat. and that of the Am. Soc. of Civ. Engrs. is shown in the requirements, while the formulas for figuring reinforcing are those of the best modern text-books on reinforcing design.

Ira H. Woolson, cons. engr. for the Board, is the compiler of the volume as a whole and is to be congratulated on the thoroughness with which he has done his work.

"Because We're Here"

MANY conventions, conferences, congresses and the like are perfunctory. They are characterized by the banquet song: "We're here because we're here," and other reasons are not always evident. This usually is not due to any outstanding fault of the men on the programs. A convention is good when it is spontaneous. It is a joy and a help to the common delegate when a few live matters are thoroughly gone into. The common man may not have correlated his knowledge as it has come to him on the job. He may not have it all correctly phrased on neatly typewritten sheets. Yet his testimony in 3-minute doses is worth while. Other delegates will have to screen, wash and grade the convention aggregate, but when they get through they will have a dense material. This is a suggestion then to program committees. There is no reason why every convention should try to cover everything from the genesis of its industry. It is idle, probably to look for omniscience in program committees. They can't be sure of what are the *paramount issues* from the viewpoints of hundreds of delegates. The suggestion is ventured, however, that if such committees will not try so hard to please everybody with something about everything, they will get some strong light on a few matters instead of a misty glimmer over a large area. And all this is said with full knowledge that it is the easiest thing in the world to criticize the conduct of a convention.

Concrete Armor Backing

THE use of concrete to back iron plates on merchant vessels is ancient history. The results wherever tested have shown that when ice or even rocks have penetrated the iron plates the internal lining of concrete has stood all shocks and has proven admirable protection to the vessel.

It is, therefore, no surprise to learn that at the Navy Yard in New York they are now putting this new armor backing in the dreadnoughts and that while this is a departure and the Arizona is the first vessel to be so constructed, this new use of cement has not been adopted without thorough trial. It is stated that Naval Constructor Stockton, who built the New York, experimented on several forward plates with concrete as a backing and after a year's trial the plates were removed and the plan showed such advantages that it was recommended to Secretary Daniels.

The concrete is substituted on the Arizona for teakwood, which was formerly used for this purpose. It is stated that about $30,000 will be saved in this way in the construction of the Arizona alone and that the vessel will be improved by the substitution of concrete for wood. The Arizona will be the first battleship of any nation to be equipped with the new backing.

Going Up (?)

IN a recent article on cement prices one of our New York contemporaries turns back 10 years to the great building boom of the year 1905 and the demand for all sorts of building materials then existing, and commenting further upon the opportunity now before us for economical construction, it takes the list of the 10 leading building commodities and shows that they are all practically lower in price now than they were 10 years ago. It states, however, that nearly all materials are beginning to go up and urges all its readers to build promptly ere labor and real estate cost more and the cycle of prosperity with all its attendant advances in prices makes construction too expensive.

Concrete Resists Earthquake Shocks

AS at Messina, Italy, Kingston, Jamaica and in the great San Francisco earthquake years ago, reinforced concrete was shown to be the safest type of construction in regions subject to such disturbances, so again in the case of the earthquake in the Imperial Valley region of Southern California last spring, concrete showed its character as an earthquake-resisting building material. While nearly 100 buildings were wrecked or seriously damaged, brick work and timber construction suffering severely, the reinforced concrete buildings stood better than any other form of construction and this was especially the case at El Centro, where the new plant of the Holton Power Co. suffered no damage and where the Hotel Barbara Worth, also a reinforced concrete building, stood undamaged.

Methods and Costs in Constructing, 42-in. and 48-in. Monolithic Concrete Sewer

By E. W. Robinson, C. E.[1]

The City of San Antonio, Tex., recently voted several million dollars in bonds for public improvements in general, one of the most important of which was to provide a system of storm sewers to carry off the surface drainage. The work described herein is known as the Stieren St. storm sewer and is one of the principal lines of the system to provide for surface drainage of the streets of a portion of the residence district of the city. It starts at the bank of the San Antonio river, and while traversing a part of the city with very slight grades in any direction, in general it follows a line of natural drainage.

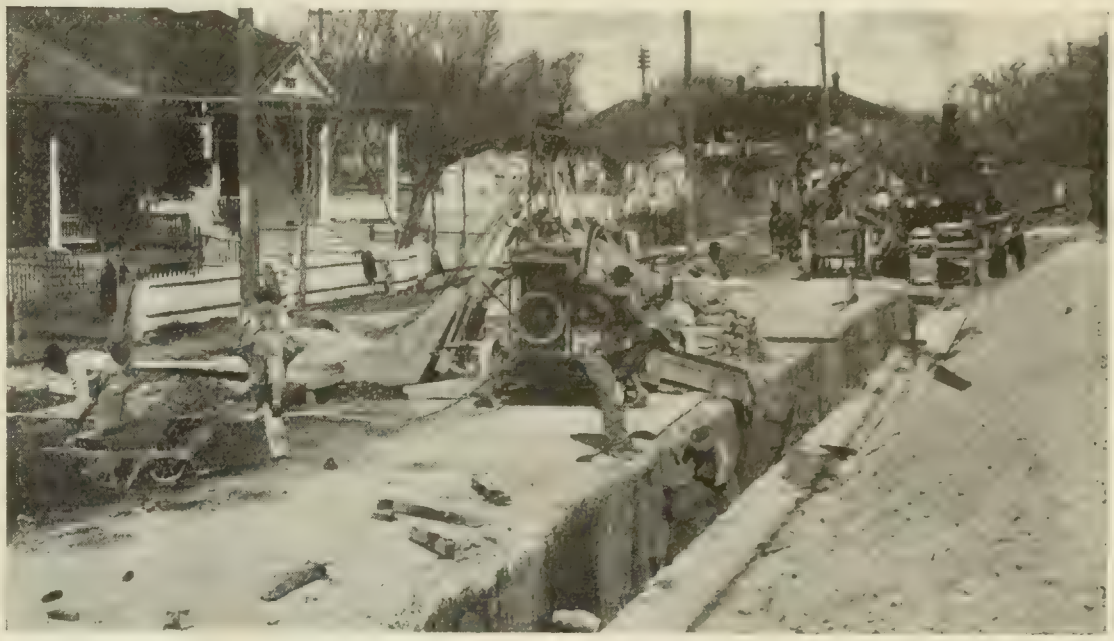

Fig. 1—Sewer Construction at San Antonio, Tex.
Note excavator and method of chuting concrete

The main line consists of 42-in. and 48-in. monolithic concrete pipe, with two short laterals of 18-in. vitrified clay pipe. One of the latter is really part of another sewer, as it empties into an existing line. Part of the concrete pipe was reinforced with Clinton electrically welded wire mesh[2] and part was plain concrete. In most cases there were from two to six inlets, without catch basins, at each street intersection along the main line. All single inlets had 12-in. vitrified clay pipe leading to the concrete pipe, and the double inlets had 15-in. and 18-in. clay pipe, depending upon the amount of water to handle. All angles in the concrete sewer were turned on curves with a radius from 20′ to 35′ on the center line. Generally there was a manhole at the tangent point of each curve and at the center of each intersecting street where the sewer was on a tangent. The streets were 50′, 55′ and 60′ wide, and with the exception of two blocks where the line was near the center of the street, it was generally about 20′ from one property line. Most of the manholes were 4′ in diam. and made of concrete. There were a few places where obstructions or other circumstances were responsible for their being larger than 4′; in these cases they were built of brick. Telescoping steel forms were used for all concrete sewer lines and manholes, the same set used on the 48-in. line being re-worked and used for the 42-in. line. All but three inlets were built of hard, shale brick laid up in cement mortar, the three being constructed of concrete. The intention at first was to build all of concrete, but owing to the fact that the inlet work had to be kept two or three blocks behind the main concrete gang on account of not wanting to shut off traffic on all streets at once at each intersection, it was found cheaper to construct them of brick than to move the mixer or mix the concrete by hand.

After getting started the organization was divided into two gangs under two foremen. The gang ahead did the excavating, laid the main sewer, poured the concrete manholes, and did part of the backfilling. The second flushed the trench, finished backfilling, pointed up the concrete sewer inside where necessary, constructed the inlets and connections and cleaned up in general. Several of the brick inlets were built by contract, the rest being built by the foreman of the second gang. It was at first thought that one foreman could run both gangs, but on account of the fact that they were necessarily scattered it was soon found that one man could not do the work properly. The second foreman undoubtedly saved his wages in increased efficiency of the men, besides doing what bricklaying was necessary. With the exception of a few white men all common laborers were Mexicans and Negroes, and on account of paying higher wages than was the custom in the city at this time, the best workers in town were secured. All except a few were experienced in this kind of work and the increased rate of pay certainly lowered the unit costs from what they would have been with cheaper labor.

All sewer pipe were paid for at a certain bid price per lin. ft. in place, according to depth. Inlets were paid for at a price each, as also were manholes for a depth of 7′ or under. For additional depth of manholes over 7′ there was a bid price per vertical ft. Loose rock excavation and all work in connection with concrete bulkhead at outlet were paid for under unit prices bid for each particular item. All unforeseen work for which there was no bid price, such as taking care of sanitary sewers which were in the way, was paid for at cost plus 15%. This item amounted to approximately $250 for the job.

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[1] Engr., McKenzie Const. Co., San Antonio, Tex.

[2] Clinton Wire Cloth Co., Boston

EXCAVATION

The job was started by doing the excavation by hand, but after the first month's work a Parsons steam trench excavator[3] did practically all the excavation. Owing to short radius of most of the curves the machine could not cut the curves to advantage, and there were several short pieces of tangent dug by hand where there were large pipes in the way or when the machine was out of commission for repairs. The first stretch of 48-in. sewer, about 800′ in length, which was dug by hand, was on an average 12′ deep and the trench was cut 5′ wide. The upper 6′ or 7′ was gravel and black loam, and the rest a white clay or adobe. Owing to the close proximity of another and deeper sewer and to the fact that it rained most of the time while the work was in progress heavy bracing and constant care were necessary to prevent caving. Two rows of rangers were put in and vertical sheeting driven about 1′ apart down to where the top of the concrete came. Each row of rangers was held with a trench jack every 5′ or 6′. Even then the clay when wet showed a tendency to slip from behind the sheathing, especially when the trench had become narrowed and undercutting was necessary to get clearance for the concrete shell. However, no ditch was lost on account of caving or slipping, but the cost of bracing on this stretch equaled or exceeded that for the rest of the sewer.

The remainder of the excavation was in hard gravel with a few boulders in places, so hard in fact that the teeth of the excavator had to be sharpened every day or two to make any progress, and minor breakdowns were frequent. The following were the widths of trench for hand excavation: For 12-in. pipe, 18″; for 15-in. pipe, 22″; for 18-in. pipe, 30″; for 42-in. pipe, 39″, and for 48-in. pipe, 48″ and 60″. The widths of trench for machine excavation were as follows: For 18-in. pipe, 28″; for 42-in. pipe, 36″, and for 48-in. pipe, 48″. On the class of material that was encountered in the machine excavation of most of the 48-in. line the trench could have been much narrower than 48″ and would have stood up well with the undercutting necessary, especially as there was very little rain while it was being cut. However, as this line was reinforced a 48-in. trench was about the minimum that would allow the rolls of wire mesh to be handed down to the form setters.

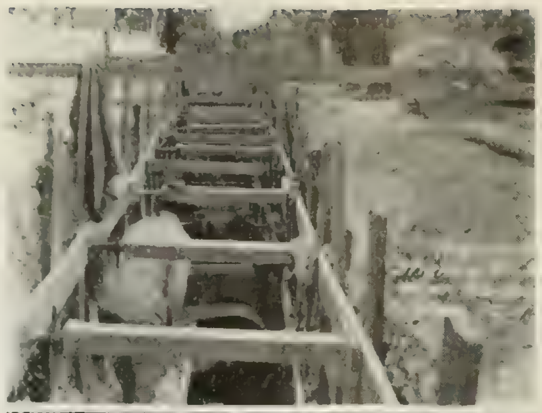

Fig. 2—Placing Sewer Forms

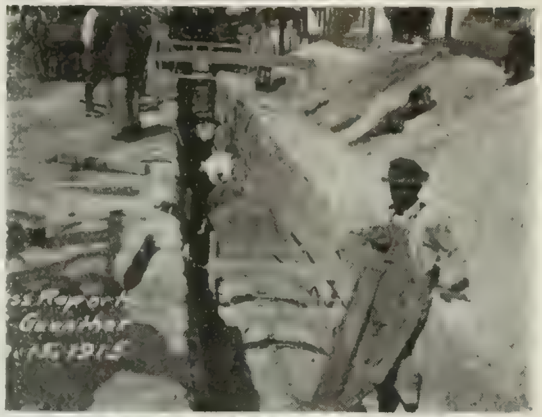

Fig. 3—Reinforcing in Place

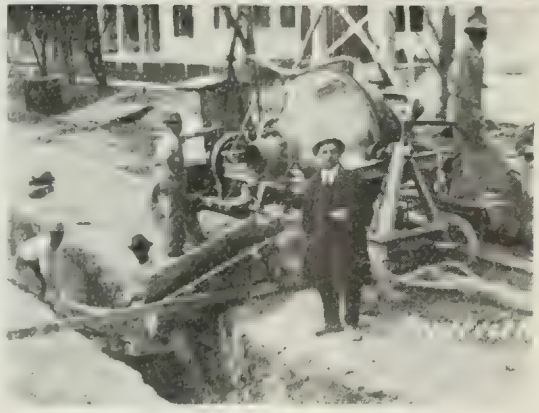

Fig. 4—Placing Concrete

The machine excavation was contracted at 30 cts. per cu. yd. for depths under 7′, and 40 cts. per cu. yd. for depths over 7′. This price was for straight excavation and did not include cost of undercutting where necessary and shaping the bottom of the trench to the proper cross-section of the concrete shell. Owing to this fact and because the curves and other short stretches were cut by hand it was difficult to separate the unit costs on excavation between different depths and between that done wholly by hand and that done in main by machine and finished by hand. With all labor receiving 25 cts. per hr. except two leaders, who received 30 cts. and 35 cts. per hr., the hand excavation in the first 800 lin. ft. mentioned above cost 60 cts. per cu. yd., solid measurement. The following is a summary of the excavation for the whole job, based on solid measurement:

EXCAVATION COSTS

Cut	Cu. Yds. Mach.	Cu. Yds. Hand	Total	Aver. Cost
0′-7′	538.5	636.7	1,175.2	$.613
7′-10′	3,235.3	469.7	3,705.0	.625
10′-12′	779.3	1,996.6	2,775.9	.595

It will be noted there is no excavation listed above as 12′-14′ cut, though there was such a classification allowed in the final estimate. This is due to the fact that the 12′-14′ cut was only a few tenths over 12′ deep and therefore no effort was made to separate the costs between that and 10′-12′.

The above costs apparently show that it was cheaper to excavate wholly by hand on this job than by machine at the contract prices paid. However, such was not the case, for the machine cut down the payroll 50% or more, considering the work being done in the same length of time, and liability insurance on sewer work was being paid at $6.00 and $8.00 on the $100 payroll. Or if a small gang had been used, the job would have taken twice as long without a machine and the overhead would have been correspondingly increased.

The contract prices for machine excavation did not include cost of taking care of any pipes encountered in the line of the trench. There were 19 water services cut and replaced at an average cost of 57 cts. each for material and $1.93 each for labor, making a total average cost each of $2.50. Fourteen of there were ½-in. galvanized pipe, three of ½-in. lead pipe laid in 3-in. clay tile, and one each of ¾-in. and 1-in. black pipe. In most cases the iron pipe was not dug up to the main, but simply cut on each side of the sewer trench and a cock inserted without turning the water off and an ordinary union used to replace the same piece of pipe taken out. There were 14 gas services cut and replaced at an average cost of 51 cts. for material and $2.49 each for labor, or a total average cost each of $3.00. Eleven of these were 1¼-in., two were 1½-in. and one 2-in. black pipe. The gas services were handled in the same manner as the water lines except that the flow of gas was stopped with a plug instead of a cock and a long-screw was used for re-connecting instead of a union. The above prices include all digging and fitting with common laborers at 25 cts. and a fitter at 45 cts. per hr. The cost of individual services varied considerably from the average, as there were so many different conditions and circumstances that governed each case. Where the location of a service pipe was overlooked and the machine cut it the cost of replacing was increased on account of having to insert all new pipe. Occasionally in a case of this kind a water service would be torn loose at the lead connection and this added more to the cost. Where the water services were wholly of lead they were dug up and disconnected at the corporation cock, and therefore the cost for cutting and replacing was wholly labor for digging and relaying.

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[3] Parsons Mfg. Co., N. Y. C.

Practically all surplus material from the excavation was loaded directly into wagons by the excavator and hauled away at once to vacant lots and low streets within a few blocks. The remainder of the surplus dirt was hauled away after the backfilling had been done and it was made sure that no more would be needed in the trench. The city and other parties had teams at the machine part of the time and altogether 541 cu. yds. was hauled off free of cost in this manner. The remaining 2,361 cu. yds. was hauled and disposed of at a cost of $.487 per cu. yd., solid measurement. Teams and drivers were paid 50 cts. per hr. and laborers 25 cts. per hr., and the above cost includes all lost time while teams were waiting at machine or at dump. It was practically impossible always to have just the exact number of teams hauling so as to keep neither machine or teams waiting on account of varying lengths of haul, different kinds of material encountered in trench and minor breakdowns of the machine.

The actual cost of backfilling and cleaning up the streets amounted to $.157 per cu. yd. of material backfilled, solid measurement. All except the final dressing up, which was done by hand, was done by two men and team with a "go-devil." This is nothing more than a light steel scraper with flat bottom and no sides. A piece of cable about 30′ long enabled the team to work on the unobstructed side of the trench. On a short piece of sewer a gasoline machine (see Fig. 9) was used to handle the scraper instead of a team.

The total labor cost of bracing trench against caving amounted to $164 for the whole job. This does not include cost of bracing for holding forms in place alone.

All ditches were thoroughly flushed with water through 1¼-in. hose connected to fire hydrants. This work was usually done by men backfilling or cleaning up street, and the cost was insignificant. As near as could be determined the labor cost of flushing was $.005 per lin. ft. of concrete sewer. The shallow pipe lines were tamped instead of flushed. Thirty das. after finishing the job the trenches have not shown the slightest settlement, notwithstanding our having had three excessively hard rains.

FORMS AND REINFORCING

Three men in the trench and one or two on top handled the forms and

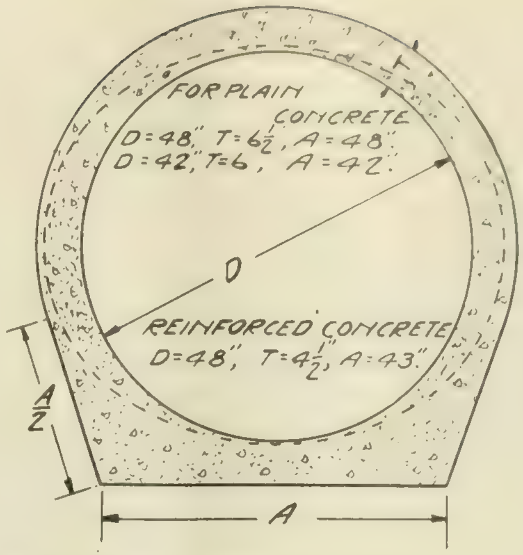


Fig. 5—Typical Sewer Section

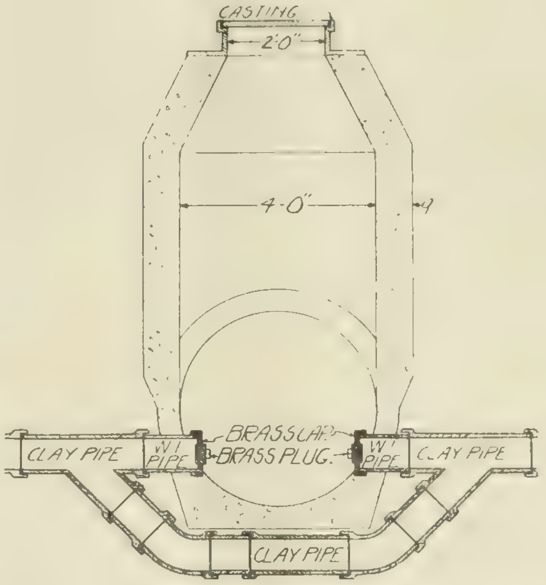


Fig. 6—Section of Manhole and Siphon

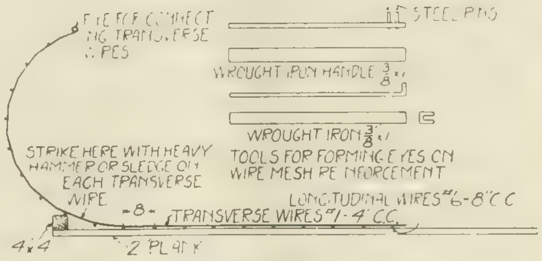

EYE FOR CONNECTING TRANSVERSE WIRES
STEEL PINS
WROUGHT IRON HANDLE 3/8×1
WROUGHT IRON 3/8×1
TOOLS FOR FORMING EYES ON WIRE MESH REINFORCEMENT
STRIKE HERE WITH HEAVY HAMMER OR SLEDGE ON EACH TRANSVERSE WIRE
LONGITUDINAL WIRES #6-8" C.C.
-8-
TRANSVERSE WIRES #1-4" C.C.
4×4
2" PLANK

Fig. 7—Method of Bending Reinforcing

reinforcing for a day's run, which varied from 50 lin. ft. to 120 lin. ft. The first section of steel form pulled forward was expanded inside the last section set previously. Concrete block which had been placed on grade and line in the trench bottom supported the forms the proper distance from same. Where wire mesh reinforcing was used the tops of the block were so shaped as to allow the mesh to rest the proper distance below the forms. The reinforcing was bent into cylinders and tied on the bank and handed down into the trench as needed. The forms were held to line by means of knee braces thrust down between them and the trench sides, which were withdrawn as the concrete reached the springing line. A 2-in. x 12-in. ranger was placed along each side of the trench about 1′ above the top of the concrete and held in place by sewer jacks over each joint of the steel forms, which was approximately 4′. Short pieces of 2-in. x 4-in. stuff were cut to proper lengths and used as struts between the jacks and the tops of the forms to hold the latter to grade until the concrete covered the top, when they were removed. This method was very effectual and in only a few cases did the forms rise from the buoyancy of the wet concrete. The cost of this bracing was included in the cost of placing forms.

An effort was made to separate cost of placing reinforcing from that of placing forms, but as the same men generally did both, and as the former was small compared with the latter they were run together. One form man received 30 cts. per hr. and the rest 25 cts., except occasionally there was a second man in the gang at 30 cts. The average cost of placing forms for the whole job amounted to $.168 per lin. ft. of sewer, the 42-in. costing practically the same as the 48-in. There were 208 lin. ft. of forms on the job and these were sold as junk at the end of the job at 1 ct. per lb. The net cost of the forms for the whole job was $585 or $.123 per lin. ft. of sewer.

Wire mesh reinforcing was bent and tied at a cost of 3 cts. per lin. ft. of sewer, or $5.54 per ton. The

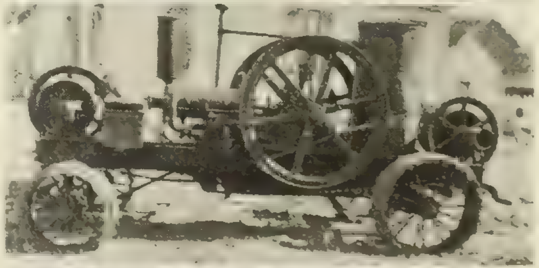


Fig. 8—Excavator at Work

Fig. 9—Gasoline Rig Used for Back Filling

Fig. 10—Retaining Wall and Sewer Outlet

men doing this usually received 25 cts. per hr. As shown in Fig. 7, the bending was done by hammers, the resultant curve being really a polygon with 8-in. sides, instead of a circle.

CONCRETE

Concrete was mixed in a ¼-cu. yd. batch mixer, gasoline-driven, and in most cases chuted into place by means of two steel troughs 12′ long. The aggregates were so placed that the mixer was moved about 25′ each time. Where the cut was shallow it became necessary to have one extra man or more raking the concrete down the troughs when placing anywhere other than directly opposite the mixer. Concrete up to the springing line was made "sloppy" so as to flow well around the reinforcing and not form pockets in the shell. No outside forms were used and it was necessary to make the concrete rather stiff for the top third of the sewer so it could be shaped properly and not waste too much. The proportions of the mix were 1 Portland cement, 4 washed river gravel, and 2 crushed limestone. The river gravel contained an excess of excellent sand and the resultant mix was a dense concrete similar to a well graded 1:2:4 as usually specified.

All concrete laborers received 25 cts. per hr. except the mixer man, who received 45 cts., and one other who worked part of the time dressing up the surface, who received 35 cts. per hr. The actual cost of mixing and placing concrete for the whole job was $1.098 per cu. yd., which includes the cost of pointing up the inside of the sewer where necessary. Some reduction could have been made in this cost had a self-propelling mixer been used, as no small amount of time is wasted in moving a mixer by hand. From observation on similar jobs where they were used the writer is of the opinion that a self-propelling mixer of the paver type is best adapted to this kind of work. Also the higher the discharge from the ground the better, because the concrete can be chuted farther each way from the mixer and the number of moves reduced.

MANHOLES

Both inside and outside forms for concrete manholes were of steel, except the inside form for the conical part at the top. This was made of wood in eight parts, so that the pieces would come out of the reduced opening at the top after the concrete had set. The inside form for the straight part was one regular section or more of the 48-in. sewer forms, and these were taken out before the top part was poured. No attempt was made to cut the inside forms to allow the steps to be placed in the walls as the concrete was poured, and they were grouted into place in holes drilled before the concrete was hard but after the forms had been removed. The same method was pursued where clay pipes from the inlets entered the manholes or the walls of the sewer barrel.

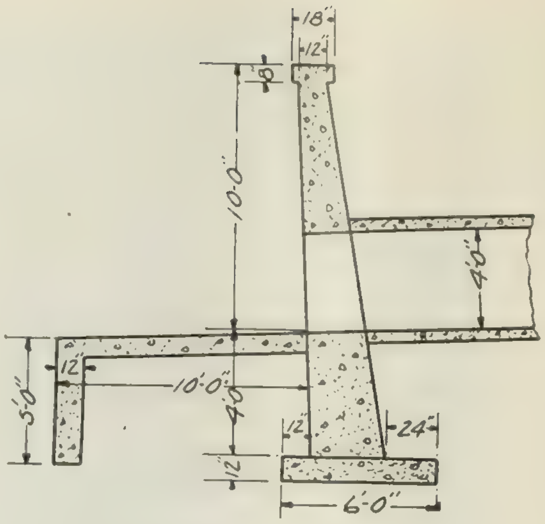


Fig. 11—Section of Outlet

There was practically no additional excavation for the manholes and the actual average labor cost per manhole for the whole job, 7′ and less in depth, was $6.55. The cost per vertical ft. for depths greater than 7′ was 96 cts. These costs included setting forms, pouring concrete, removing forms, pointing up where necessary, setting casting, cutting holes for steps and pipes and grouting the latter in place. This cost is an average of 27 manholes, seven of which were of brick on the clay pipe line or where obstructions would not allow the use of concrete. In three cases a sanitary sewer intersected the concrete line about half way between invert and crown, and in these places a 5-ft. manhole was built so as to give additional waterway to offset the obstruction of the sanitary line. The clay pipe of the latter was replaced by a piece of iron pipe where it passed through the manhole. In one instance, when the sanitary line came so near the invert of the concrete pipe as to cause liability of sticks, etc., lodging and forming too great an obstruction, the sanitary line was carried under the storm sewer by means of a siphon, as shown in Fig. 6.

INLETS

The average total labor cost of all inlets, which includes three of concrete and 64 of brick, amounted to $5.18 each. This cost includes labor on excavation and backfilling, concrete bottoms and curb above openings, laying brick, plastering inside with cement plaster and setting casting. All labor received 25 cts. per hr. except the bricklayer, who received 50 cts. per hr. On several the brick laying, plastering and setting casting was contracted at $2.50 each, and on a few others at $3.50 each. The insides of the basins were 2′ 4″ x 2′ 1″ and on an average of about 3′ 6″ deep. The front and the side walls were 8″ thick, and the back wall 4″ thick. The short section of curb placed over the opening was reinforced with two ½-in. twisted square steel bars.

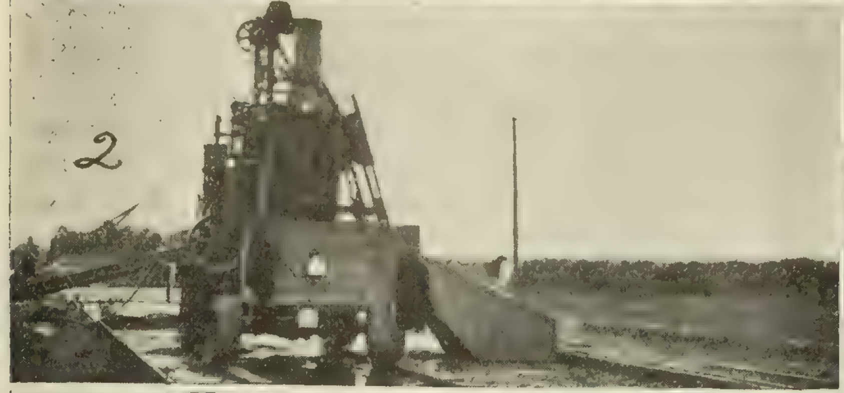
HEAD WALL OR BULKHEAD AT OUTLET

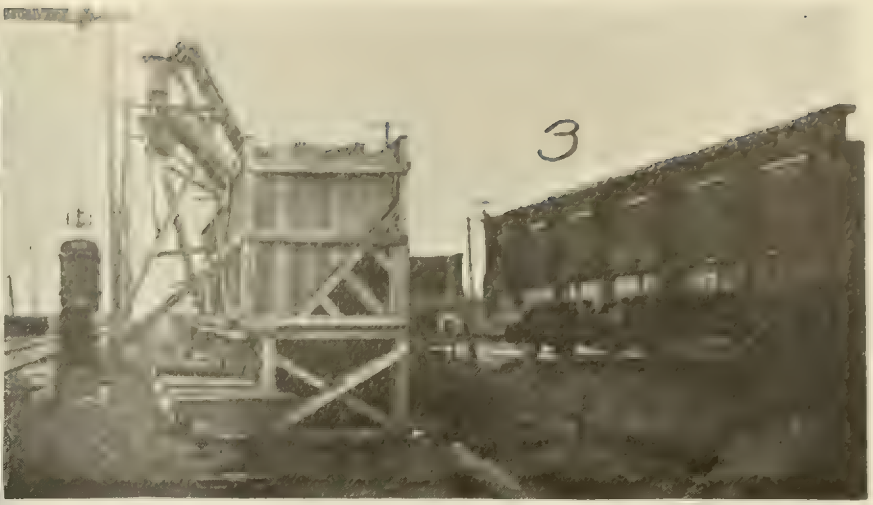
Where the main line emptied into the river a reinforced concrete bulkhead (see Figs. 10 and 11) was constructed to retain the earth fill and protect the end of the pipe. There were 131 cu. yds. of excavation in this work, which, with laborers at 25 cts. per hr., cost 47 cts. per cu. yd. There were 1,000 sq. ft. of form surface touched by the concrete which cost $.042 per sq. ft. for labor alone to erect. Carpenters were paid 45 cts. and helpers 25 cts. per hr. on this work. The cost of mixing and placing 57.1 cu. yds. of concrete was $1.08 per cu. yd. Concrete was mixed about 75′ from the wall and wheeled in wheelbarrows on runways to the forms. The walls were reinforced with the same size of wire mesh as was used in the sewer, and in addition had ½-in. and ¾-in. twisted square bars for dowels to tie the wall into the base and the footing.

All the above costs include supervision, night-watch, time-keeper, and in fact all field labor connected with the work. This item called "general" labor amounted to 17% of the total payroll and was apportioned to each item for which a separate record was kept.

The above work was done by the McKenzie Const. Co. and under the supervision of M. C. Irwin, asst. city engr. in charge of sewer construction of the city of San Antonio. Samuel M. Gray, Providence, R. I., is cons. engr. for the city on all sewer work under construction from the recent bond issue.

In the early stages of reinforced concrete construction, it was but natural that it required more time to erect buildings of this kind. They were new. But with the specialization of architects, engineers and contractors on reinforced concrete, it has now come to be the most rapidly built of all forms of non-burning construction.—*Knickerbocker Komments.*





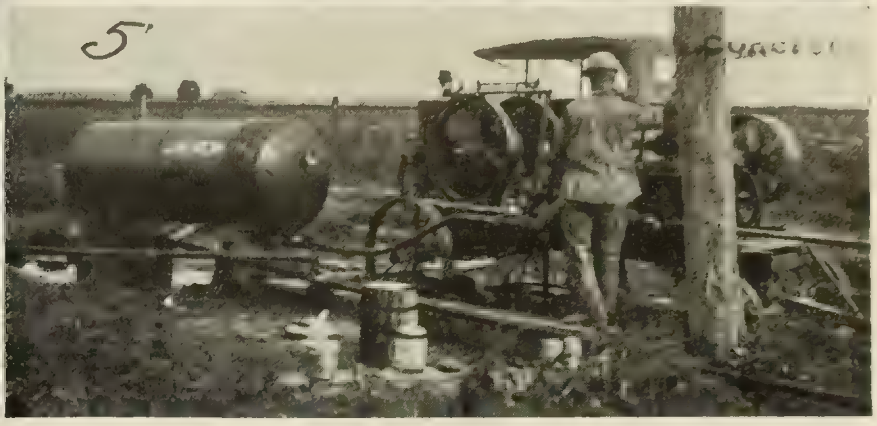


Fig. 1—Industrial Railway on Road Contract
Fig. 2—Special Mixer of 36-cu. ft. Capacity
Fig. 4—Cement Sheds on Road Job

Fig. 3—Sand and Gravel Bins
Fig. 5—Portable Pump, Pressure Tank and Pipe Line

Economical Handling of a Large Concrete Road Contract

(contributed)

An unusual thickness and richness of concrete as well as up-to-date methods of handling materials marks the construction of 11½ mi. of concrete pavement on the Lincoln Highway between South Bend and New Carlisle in St. Joseph Co., Ind., one of the largest single concrete road contracts ever let.

Previous to this year the road had been like hundreds of other Indiana roads—an old gravel surface dating back probably more than 50 years, on which little maintenance work had ever been done, other than that by farmers "working out" their poll tax. Present heavy traffic and the certainty of increase rendered this type inadequate so it was decided to improve the road with an 18-ft. concrete pavement and a bond issue was passed for that purpose.

Jacob Ackerman, of La Porte, Ind., and A. Runyon, of Valparaiso, Ind., under the firm name of Jacob Ackerman & Co., secured the contract at a price of $174,675, or a little more than $15,000 per mi., which included grading, bridges and culverts, etc.

Grading was begun on the New Carlisle end of the road in May, 1915, and, with a ⅝-yd. Thew steam shovel, from 25 to 35 teams, a 10-ton road roller, grading machines and the rest of the ordinary equipment for such work, is being carried on expeditiously. In general the country is fairly level, but toward the South Bend end there are cuts ranging up to 12′ in depth and at this point the steam shovel is being used.

The contractors gave considerable time to studying out the most economical methods of carrying on the work of building the pavement proper. This was their first concrete contract, all previous work having been on macadam and brick paving. Therefore, realizing that a large new equipment was necessary, they set about to make it as complete and labor saving as possible.

Hauling and handling materials appeared to furnish the greatest field for a scientific layout of the work and after looking into various methods, an industrial railway equipment[2] was purchased, consisting of a locomotive, 45 V-shaped, side-dumping cars and about three miles of 2-ft. gauge track.

The problem then arose of transferring the materials from the cars to the mixer and after consultation with the manufacturers a specially designed mixer[3] with a skip placed at right angles to the axis of the drum was ordered. In addition to its position, the skip was built of a size such that, when lowered, its outer edge came within a few inches of the side forms. The paver, according to all records, is the largest ever built, having a capacity of 36 cu. ft.

The method of operation for which this design was made is as follows: Each car is loaded, as will be described later, with sand, gravel and cement in proper amounts and proportions for one complete batch for the mixer. Running alongside of, and as close as possible to the road, as shown in the illustration, the side-dumping cars discharge their contents directly into the skip without rehandling. With this essential principle in mind, around which the layout of the work was built up, the other operations will be described in order.

Sand, gravel and cement are delivered by the Chicago, Lake Shore & South Bend electric railroad, which parallels the road for its en-

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[1] Thew Automatic Shovel Co., Lorain, Ohio

[2] Orenstein-Arthur Koppel Co., Koppel, Pa.

[3] Marsh-Capron Mfg. Co., Chicago

tire length, the distance between the two averaging about 1/4 mi. At a point about three miles from New Carlisle, where the railroad runs on a fill, a siding was put in and the sand and gravel bins and cement sheds erected as shown in Fig. 3. The industrial track runs on the other side of these structures and on the ground level, several feet below the levation of the electric line.

The aggregate bins are built in one unit and of an equal capacity for sand and gravel, the sand being located on the side nearest the dead end of the industrial track. The cement sheds are about 200′ nearer the road or mixer end.

The gravel and sand cars of the electric road are of the Hart convertible type with a capacity of about 30 yds. each. In unloading to the bins, the material is dumped through the bottom into a hopper built under the siding, whence it is elevated by a bucket conveyor and chuted into one or the other bin through a metal trough. The bins are rather small, holding only a little over a car load each. This was unavoidable, however, because of lack of space, another electric interurban line running close by on one side and the L. S. & M. S. R. R. on the other. Had there been plenty of room, 75-yd. bins would have been built.

From the bins and cement sheds to the mixer, all materials are handled by the industrial railway in trains of 15 cars each. As before stated, each car holds a complete batch for the mixer. To accomplish this each car is first run to the sand bin and loaded through a chute in the bottom of the V-shaped bin, with 9 cu. ft. of material, measurement being made by a template fitting the car. Passing to the gravel bin 15 cu. ft. of this material are added in the same manner. Finally at the cement shed, six sacks of cement are piled on top.

The cement is the only material not handled entirely by mechanical means. If this material were received in bulk instead of sacks it would be entirely feasible so to lay out the plant and equipment as to handle this material mechanically as well, and at quite a saving in cost over the present method.

With a total of 45 cars, the use of 15 to a train is seen to be the economical arrangement, each car working the maximum possible amount. At all times one train is being loaded, one unloading at the mixer and one in transit. Only two turn-outs are required, one at the mixer and the other at the bins.

The many merits of this complete yet simple system of transporting materials are easily understood. First of all are speed and certainty of operation. Although the work has been delayed so far due to bad weather and difficulty in getting materials, it is probable that some new speed records for concrete road construction will be made before the season is over. At this writing 450′ have been laid in one 10-hr. day, and with all links in the chain running smoothly, this can be exceeded easily.

Another record is that of unloading 15 cars, mixing, placing and finishing in 30 min. At this rate without undue delays or breakdowns, more than 500′ can be laid in 10 hrs.

A second advantage is that very few men are required as compared, for example, to a layout using wagons and wheelbarrows for handling materials. Exact figures as to the most conomical crew, however, are not yet available.

As nothing is transported over the sub-grade no second leveling off is required. On jobs where the latter is necessary it is extremely difficult to obtain a firm, even, flat surface after being cut up by wagon wheels.

No material is lost by getting mixed up with earth or trampled into the sub-grade. Also clean materials are secured,—none of the sub-grade is shoveled into the skip.

There is little chance for much cement getting wet in a rainstorm and there is no cement pile for a leaky hose to play on.

Correct proportions of materials are more certain to be obtained. Measurement in cars is more simple and accurate than in wheelbarrows.

The handling of the water supply for this road also has many features worthhy of notice. It was estimated that a total of 18,000 gals. per da. would be required for the mixer and for curing the concrete. Accordingly four wells were driven alongside the road, their first location being about two miles from the beginning of the work—the New Carlisle end. A 6-h. p. kerosene engine furnishes the power to drive the pump, both engine and pump being mounted on wheels as shown in the illustration. A pressure tank insures a steady pressure of 30 lbs. per sq. in.

The pipe line is 2″ in diameter and with this pump and pressure tank sufficient water can be delivered for more than 2½ miles over fairly level country. At intervals of 150′ along the pipe line there are T's allowing connection for a 1-in. hose. Cut-out valves are placed about 700′ apart.

Specifications for the concrete, which were drawn up by Henderson McClellan, Co. Engr. of St. Joseph Co., differ considerably from common practice but lean toward what might be called the safe side. Principal among these is the 1:1½: 2½ mix which is probably the richest ever used on a one-course pavement of this character. The pavement slab, which is placed on a flat sub-grade, is 9″ thick at the center or 1″ greater than the common figure according to present practice. As the thickness at the sides is 6″ the crown becomes ⅓-in. to the foot instead of the ordinary slope of ¼-in.

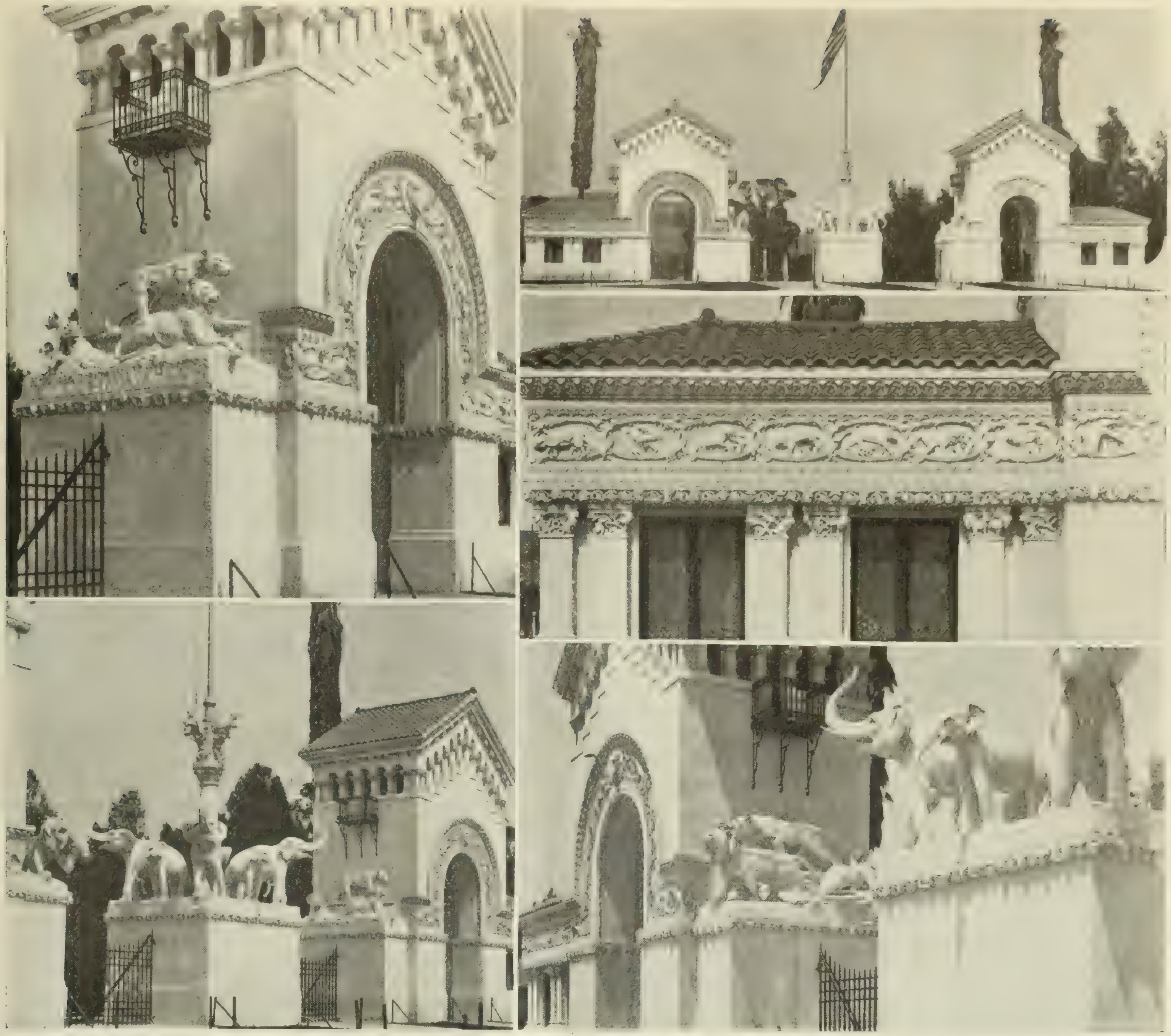
Placing, finishing and curing the concrete are done in the ordinary manner and so will not be described in detail. The mixer is equipped with a 12-ft. chute. Steel side forms of the ordinary channel section are used. Transverse joints protected with steel plates are spaced 30′ apart at right angles to the center line.

U. S. Employment Bureau

The U. S. Government, through the Dept. of Labor, has inaugurated, as a part of the Division of Information, a countrywide employment bureau. The underlying principle of the work is, perhaps, best expressed by the Secretary of the Dept. of Labor in the following words:

> The Dept. of Labor has established Distribution ranches throughout the country for the purpose, on the one hand, of developing the welfare of the wage earners of the U. S., and improving their opportunities for profitable employment, and, on the other hand, of affording to employers a method whereby they may make application for such help as they need, either male or female, citizens or alien residents, and have their wants supplied through said Distribution ranches.
>
> First, the U. S. has been divided into 18 sections, or "Distribution Zones," as they are called, and in each of these zones an employment office has been opened. These zones are subdivided and in fact every post office acts as an agency. Blanks obtained of the Postmaster can be filled out by employer or those seeking employment and will be transmitted to division points where they are properly registered. Reference is given to those in the employers' own town or nearby points, but by means of bulletins the bureau is in touch with the supply of labor throughout the country. No fee is required from employer or employee.

As a result of the course in cement work conducted by the county agent at the Industrial Arts High School at Sterling, Col., the women farmers of Logan county have gone to work making concrete posts, floors and steps. Along with the men farmers they attended the talks and demonstrations in concrete and are now perfecting what they learned by doing the thing itself.



Entrance Details, Selig Zoo, Los Angeles, Cal.

Ornamental Concrete Entrance of Selig Zoo, Los Angeles, Cal.

By W. C. Sawyer

The Selig Zoo, recently opened to the public in Los Angeles, Cal., opposite Eastlake Park, has for an entrance one of the most interesting pieces of ornamental concrete casting on the Pacific Coast.

The modeling was done in clay. The casting was done in plaster and glue molds. A small amount of finishing was done with the chisel. At each side of the roadway at the entrance is a tower of pleasing architectural design, pierced by an archway through which foot passengers enter. On either side there is an attractive building, one a ticket office and the other a switch-room.

The main frieze contains a large number of finely modeled birds and animals in bas relief, there being no two alike.

In the molding surrounding the entire structure is worked out a continuous procession of animals' heads, several hundred in number and again no two alike. It is said that the designer exceeded the limits of zoology in search of suitable specimens and was compelled to adopt some from mythology.

The entrance is of white concrete, with red tile roofs. The entire structure is of concrete, the walls being 18″ thick.

The center group of eight nearly full-sized elephants is unusually interesting and like-like, as are also the animals on the pedestals adjoining the towers opposite to them. The entrance cost nearly $75,000.

Truly, extremes meet. It is not enough that a building be fireproof. It should also be waterproof, so that in case the contents of the upper floors are aflame, the water thrown on the fire will not drip down and spoil everything on the floors below. Without doorsills raised a little above the floor level and curbs around other openings on the floor, any water in a reinforced concrete building is drained off the impervious floors by scuppers.—*Knickerbocker Komments.*

The Construction of Small Concrete Houses at San Juan, P. R.

By Earl K. Burton[1]

The concrete house has not developed so rapidly as its excellence over many more commonly used materials warrants.

This apparently slow growth is due, more than to any other one thing, to the fact that we as a nation of builders have too long thought in terms of other materials. This applies alike to the architect, the builder and the mechanic.

Instead of grasping the opportunity to develop the best in a wonderful material, indifference has been manifested by those most capable of giving concrete its proper development.

In far too many cases those most active in its use have been persons who had little idea of architectural design, who have not realized that new material, new textures and new construction methods must mean the development of a proper architectural expression, and the results of their well meant efforts have hindered rather than hastened the use of concrete.

The accompanying illustrations suggest the beuaty of concrete home architecture in competent hands. The Spanish architect has long been accustomed to the use of stucco and tile, and he apparently finds easy a task that has been too often bungled.

The construction methods illustrated are simple and the costs, in view of the prices paid for material and labor, and the results obtained, are not high.

It is well to note that while the single wall construction described would no doubt be satisfactory in a genial climate like that of Porto Rico, in the north a double wall would be required, built either of structural concrete or secured by means of furring and lath.

Since the inauguration of reinforced concrete residences of the bungalow type in Porto Rico some five years ago, they have gained much favor among Porto Ricans and American residents of the island. This type, which is exemplified in the accompanying illustrations, is the standard of construction in the residential district of San Juan known as "El Condado."

This modern reinforced concrete dwelling is in marked contrast to the type of Porto Rican residence formerly built and still in use to a large extent. The old structures usually consisted of very heavy brick walls ranging in thickness from 18″ to 24″ and plastered both inside and outside with a mortar of pulverized brick and natural cement. Occasionally one would find the interior partitions of the same thickness as the outside walls, although they supported only the roof. This type depended for durability and strength upon its massiveness only. The arrangement of the interior was very simple, usually rectangular in shape with one hall or passageway extending the entire length of the building and with rooms located symmetrically on either side of the hall.

The modern dwelling, the construction of which is here described, is architecturally similar to the American bungalow. Its outside appearance would seem identical with bungalows in California and other parts of the U. S., and essentially it is, but several features are included that make it distinctive, both from necessity and from local artistic temperament. For example, shutters are installed in nearly all window openings. They permit practically 100% ventilation and at the same time diffuse the intensely bright sunlight. Also, the Porto Rican is a lover of tile floors and of colors that give contrast. Tile floors will be found in some parts, if not all, of the house, and faience tile panels are inserted in the outside walls. The living room and the dining room are generally thrown into one large room, there being either a wide arch or columns and grill separating them. These are customs that have prevailed in Porto Rican homes for years.

STRUCTURAL FEATURES

The footings and the outside walls are constructed of reinforced concrete, the latter extending to the full height of the building. The footing usually consists of a solid course of concrete 9″ to 1′ in thickness and 2′ 6″ to 3′ 6″ in width. In some cases footings have been placed in filled ground below sea level and very close to the shore, in soft sand. This has necessitated the construction of a spread footing of unusual width and depth, heavily reinforced. Such a footing acts in the same manner as the so-called "raft" foundation. A footing wall 10″ thick extends from the footing to the floor line and is offset here to form a belt course around the building on the outside and a bearing for the floor joists on the inside. For one-story structures the wall above the floor has been constructed of reinforced concrete 4″ thick or of metal lath and plaster on studs. In the latter, the wall is 6″ thick. The footing and footing wall concrete is mixed in the proportions of 1:3:6, using American brands of Portland cement, river sand, if possible, but usually sea sand, and broken stone (a blue trap-rock of excellent quality), ranging in size from ½″ to 1″. The footing and footing wall are poured monolithic around the entire building and the former is reinforced with from three to five ¾-in. bars longitudinally and ½-in. bars transversely, spaced 24″ o. c. The footing wall is reinforced with ½-in. bars spaced 12″ horizontally and 24″ vertically. The 4-in. concrete wall has the same reinforcement as the footing wall. Four inches may appear thin for a wall supporting a roof and it would seem that it would be hard to pour so as to obtain a smooth surface and to eliminate the "honeycombs." The latter objection is overcome by the use of a mixture of Portland cement and screenings mixed 1:5. The screenings are the hard trap-rock mentioned above and range in size from ¼″ to the smallest particle. This mixture gives a very smooth wall and little additional work is necessary after the removal of the forms. While such a wall is durable, yet its compressive strength is rather low, but experience has shown that it is amply strong to support a roof of ordinary wood construction, the type which is ordinarily used. With a roof of heavy tile, such as is shown in Figs. 1 and 6, the use of a 4-in. wall would not, in the writer's opinion, be considered good practice where the outside walls carry the entire roof. As an added factor of safety, and to prevent cracks that have occasionally appeared in the 4-in. walls, specifications that call for a solid concrete wall have been changed to a 6-in. wall. The chief advantage of the use of screenings

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[1] Res. engr., Trussed Concrete Steel Co., San Juan, P. R.

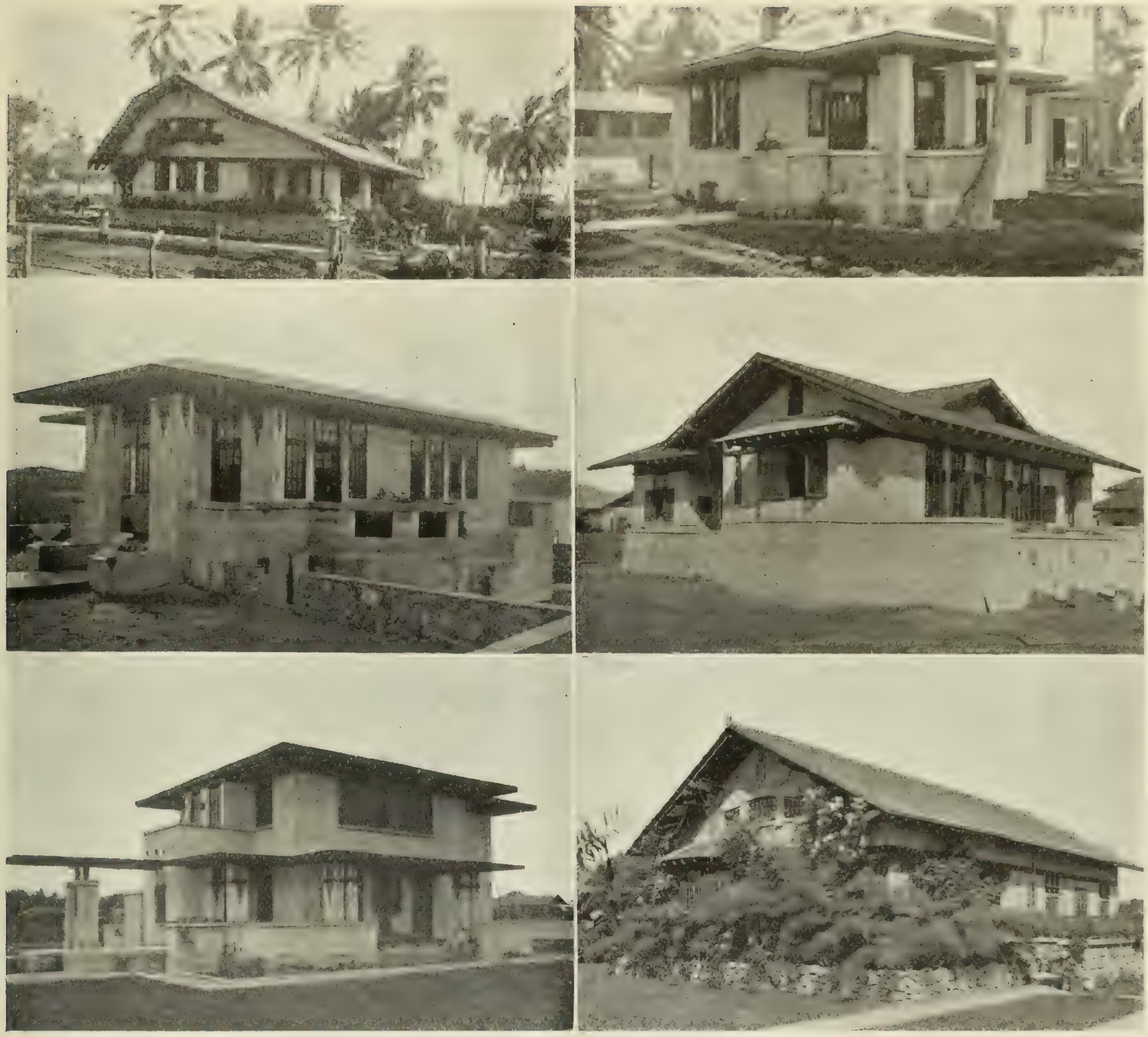

Fig. 1—A Group of Concrete Houses at "El Condado," Porto Rico

is the pleasing texture of the finished surface.

The concrete is mixed by hand to a wet consistency and the wall is poured in courses 3′ high around the entire outside. The forms are removed 24 hrs. after pouring the concrete and the wall, while still "green," is rubbed down with a wooden float. In this way the rough spots are eliminated without discoloring the surface. For such a thin wall special care is exercised in placing and bracing the forms to keep them true and plumb.

Floors—The floor is usually constructed of wood, using joists 2″ x 8″, 18″ o. c., supported at the outside on the footing wall and at the center on a girder set on concrete posts. One-in. sheathing is laid directly on the joists and the finished flooring after the other parts of the building is complete. If tile floors are specified, the tile are laid on a concrete base over a well packed earth fill. The floors of the bath room and of the kitchen are generally of tile and concrete respectively. The top surface of all concrete floors is treated with a hardener to prevent wearing and dusting.

Partitions—All interior partitions are constructed of Hy-Rib[2] and plaster, except where a center support is necessary for the roof joists, in which case the center longitudinal wall is of solid concrete. The partitions are 3″ thick and are laid directly upon the wood floor, the floor joists being doubled under the partition. They are reinforced at the corners and at the sides and the top of door openings with $1\frac{1}{2}$-in. structural channels vertically, and $\frac{1}{4}$-in. round rods, attached to the Hy-Rib, horizontally, 18″ o. c. The mortar applied to these partitions consists of 1 part of Portland cement, 3 parts of sand and a small amount of lime, usually 10% of the cement. The interior of the outside walls is also plastered to conform in color and texture to the plaster partitions.

All concrete and plaster are waterproofed with an integral waterproofing, as well as all concrete floors that are laid on the ground.

Roofs—If the width of the building will permit, the roof joists span the outside walls. Roof construction is of the ordinary frame type and is clearly shown in the accompanying plans. The roofing material used depends upon the fancy of the owner and is of asphaltic paper, metal tile, Spanish clay or vitrified tile. The clay tile are not used to a very large extent, owing to their exceptionally high cost. The pitch of roofs is very flat and the overhang varies from 3′ to 4′, either ceiled or

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[2] Trussed Concrete Steel Co., Youngstown, Ohio

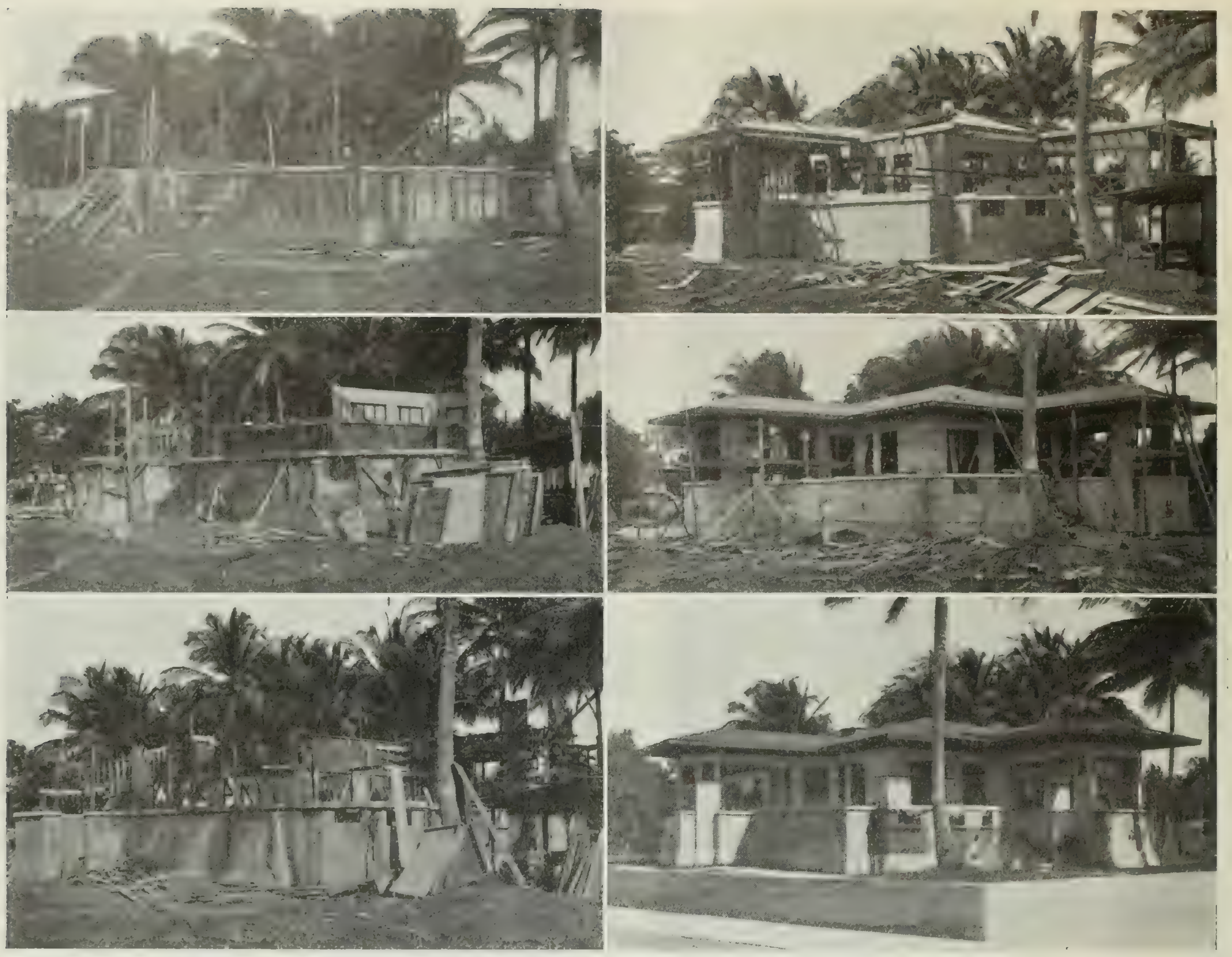


Fig. 2—Construction Views of House for Behn Bros., El Condado, Porto Rico

left open. If ceiled, special care is taken to allow circulation in the attic by providing at intervals screened openings in the ceiling.

Details of Finish—The tendency of the Porto Rican is toward rather bright colors and panels of faience tile are inserted in certain parts of the outside wall, usually on the sides of columns and at the lower corners of windows. These panels are shown in the accompanying views. The windows are a very important factor in the construction of these dwellings, as it is imperative to obtain the maximum ventilation and, on the other hand, not admit too much sunlight. As before mentioned, this is

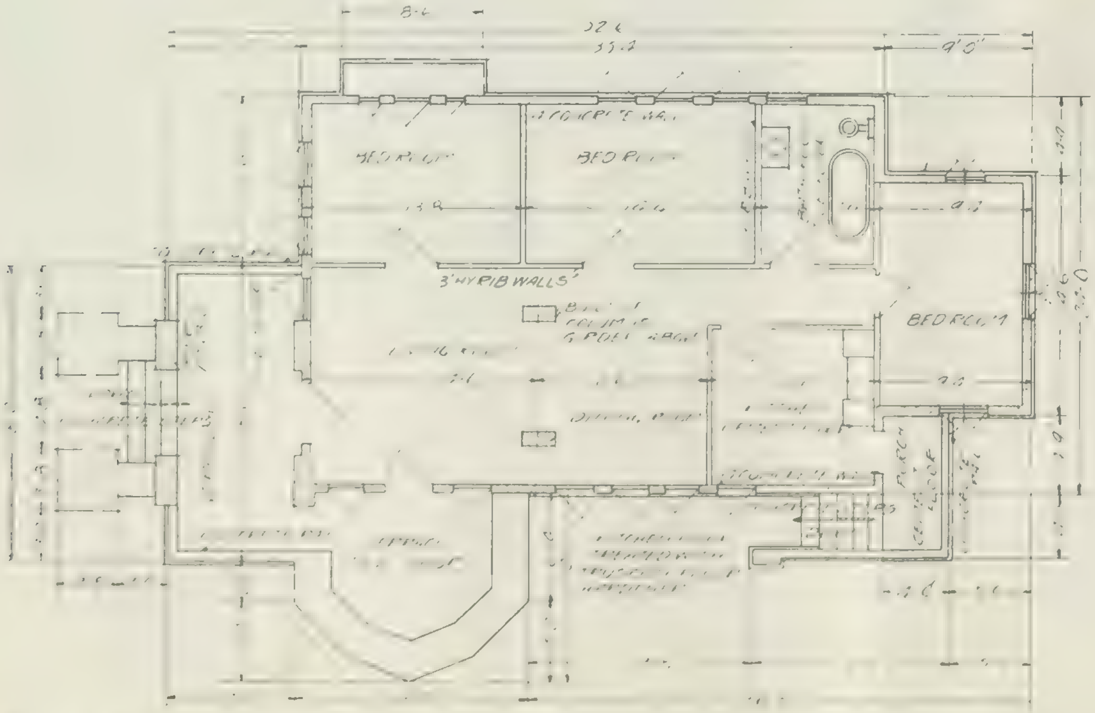


Fig. 3—Floor Plan of Behn Bros. House

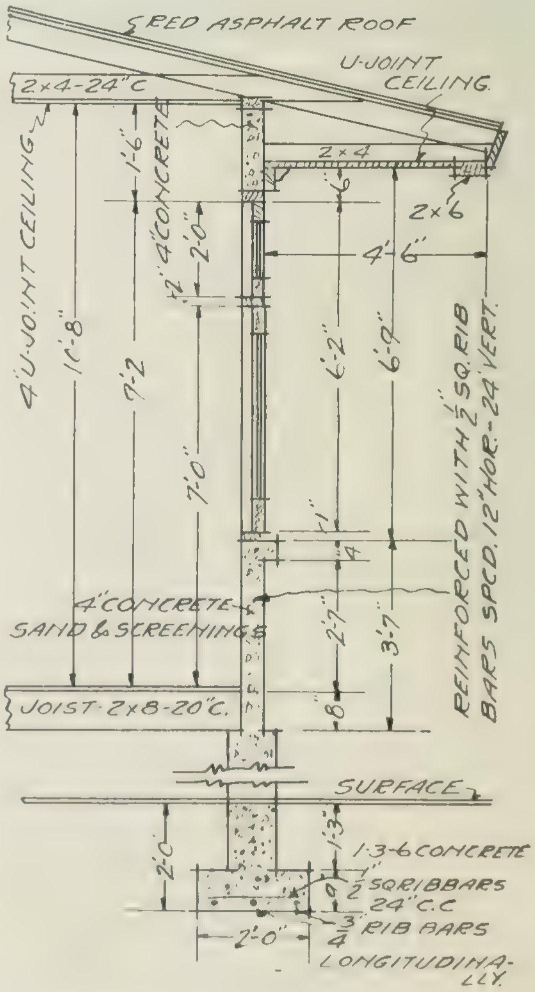


Fig. 4—Typical Wall Section

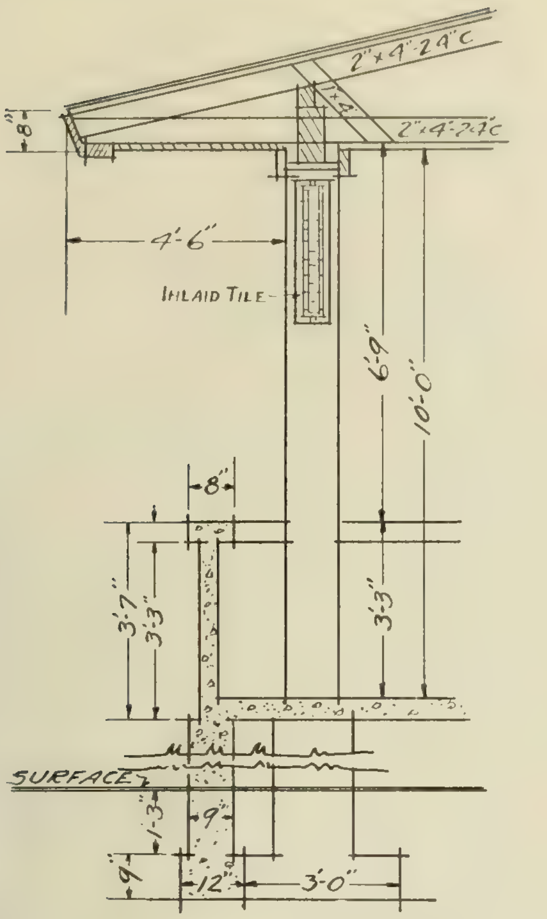
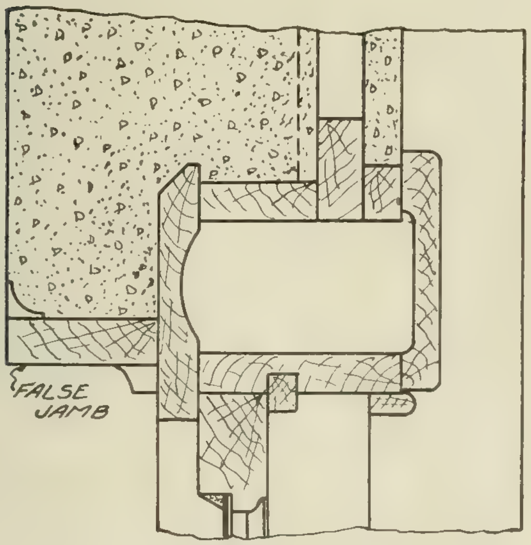


Fig. 5—Section Through Porch



SECTION THROUGH JAMB.

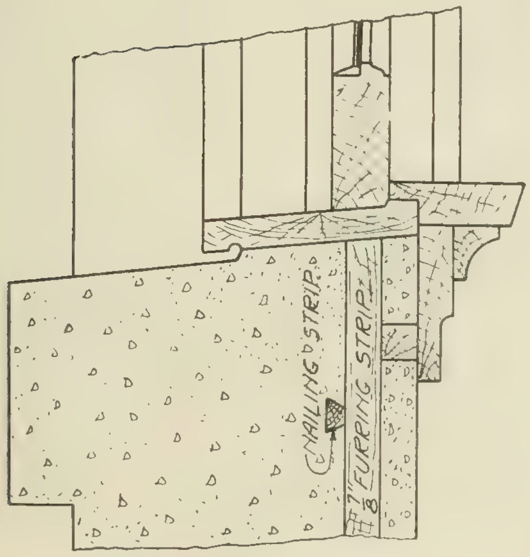


Fig. 6—Detail of Window Trim

ordinarily accomplished by the use of shutter windows. These windows are also generally placed in groups so that when they are open the room will practically be converted into a veranda.

These residences contain nearly nearly all of the conveniences of a modern suburban American home, such as water service, electricity, gas, etc. However, except in the business district of San Juan, there is no sewerage system. Sanitation, therefore, requires that each residence must dispose of its sewage. The system consists of two tanks placed well under ground, one of them constructed of concrete and practically air-tight. The second tank is constructed of loose stones through which the sewage water percolates. The solids are retained in the first tank and the fluid is drained into the second, where it seeps out through the ground. The air-tight tank will require cleaning about once a year and the outlet tank, if constructed properly, will never require any attention.

These residences are in the residential park, "El Condado," which contains practically all the homes of this type. The dwellings are designed by local architects and are built by local contractors, either under the supervision of the owner or through Behn Bros., who are financing the development of this section.

COSTS

It is rather difficult to obtain unit cost figures. Very few contractors keep a cost system in a systematic way and consequently most of them cannot give the cost of a certain kind of concrete on the unit basis. However, the following figures are an average of most of the structures illustrated and represent quite closely the actual cost.

Labor and Material Costs, Concrete Residences in San Juan, P. R.

Materials: (Cost at Job)

Cement, per bbl. gross (less 28 cts. for return of 4 sacks)	$1.80
Broken stone, ¾-in., per cu. yd	$2.30
Stone screenings, ¼-in. to dust, per cu. yd.	$1.15
Sea sand, per cu. yd	50 cts.
River sand, per cu. yd	$1.90
Rough dimension and sheathing lumber, per 1,000 b. m.	$28–30
Finished Y. P. lumber for formwork, per 1,000 b. m	$30–32
Quarter-sawed Y. P. flooring, per 1,000 b. m.	$65–70
Reinforcing steel, per ton base	$41.50
P. R. Mosaic tile for floors, per sq. yd.	85 cts.
Red quarry tile for roof (U. S. mfre.), per sq. yd. of roof	$2.50
Holland clay tile for roof, per sq. yd. of roof	$1.20
Metal lath for partitions, with studs, per sq. ft	2.5 cts.–3.0 cts.
Hy-Rib or similar for solid partitions, per sq. ft	5 cts.–7 cts.

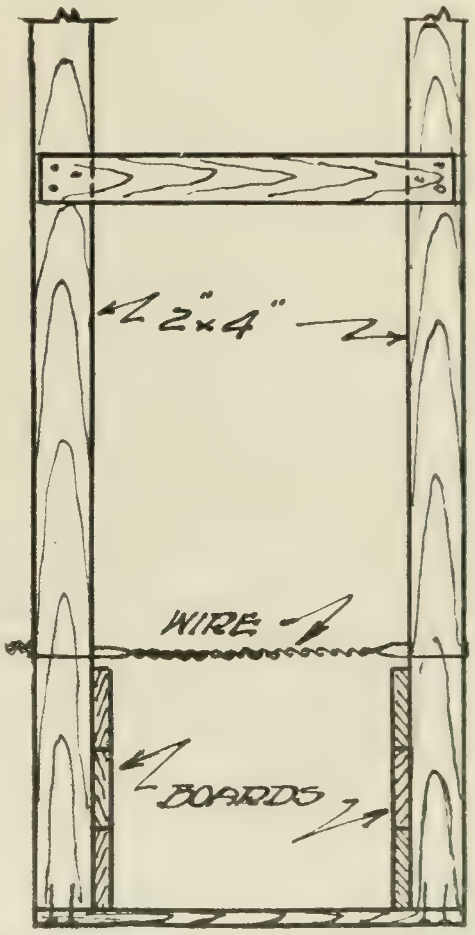
Labor and Materials:

Footing concrete, 1:3:6, labor and materials, per cu. yd	$9.00
Wall concrete, 4"–6" thick, labor and materials, per cu. yd	$18.00
Floor concrete on earth fill, labor and materials, per 100', (5" thick), (no top dressing)	$12–14
Hy-Rib partitions, 3" thick, per sq. yd	$1.75
Studded partitions, 6" thick, lath and plaster both sides, per sq. yd	$2.00
Plaster and concrete, ¼" thick, per sq. yd.	35 cts.
Rub finish on outside wall (where not plastered), per sq. yd	13 cts.
Finished wood flooring, labor laying, per sq. yd	13.5 cts.
Finished wood flooring, labor finishing and scraping, per sq. yd	16.0 cts.
Wood floor joists, 18– spacing, labor, per 1,000 b. m	$20.00
Tile floor, labor, per sq. yd	$1.00
Peon labor, per hr	10 cts.–12 cts.
Carpenters, per hr	25 cts.

Average cost of buildings, complete, including plumbing, electric work, etc., for one-story residence as described in article is $1.75 per sq. ft. of floor area, including balconies.

Saving Time in Setting Forms

When setting forms for cellars time can often be saved by putting together the studding in units as suggested by the illustration. By this



Setting Forms

method two studs can be set at once and a few courses of boards run, when the forms can be easily put into alignment.

There is perhaps a greater difference and latitude in opinions and proportions for mixing concrete than in any other phase of concrete construction. What is more, opinions and formulas are changing all the time.

For example, only a few months ago the cement world was startled by an engineer who applied microscopic tests to concrete—something which had never been done before. He found that even in the best kind of concrete work much of the cement was inert; that is, it had not been hydrated, it was not acting as "mineral glue." Not so many years ago every one thought that sand and aggregate with sharp corners were the most desirable. Rounded pebbles were taboo. Lately it has been shown by prominent engineers that rounded pebbles can also be used without detriment to the concrete.—*Knickerbocker Komments.*

Contractors To Replace $20,000 Worth of Concrete Bridge Work

By J. H. Ames[1]

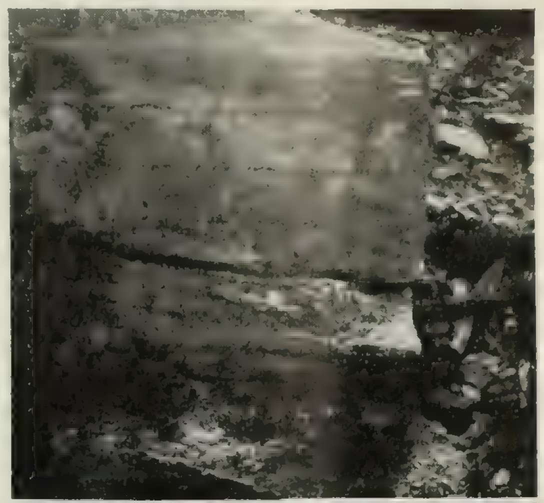
This article was written by Mr. Ames for the Service Bulletin, *which is the official publication of the Iowa State Highway Commission.*

Our genial friend, "Hap" Hazzard, was evidently in charge of the faulty work, and we know of no better way to drive home the need of care and good concrete than to publish occasional accounts of failures.

There is no implication that the faults illustrated are the exclusive property of Iowa contractors. The fact that the faulty work represents less than 1% of the total indicates that Iowa is not to be condemned for laxity beyond other states. Mr. Ames pointedly shows how unnecessary it is that the work described should have been defective. We doubt that Mr. Hazzard has continued in the employ of the contractors who must replace this work.

Within the past few weeks the Iowa State Highway Commission has been called upon to make an examination to determine the acceptance or rejection of a number of bridges constructed in this state last year. Nearly $20,000 worth of concrete construction has been rejected on account of careless construction or the use of poor materials. While this amount is only approximately 7/10 of 1% of the total amount of work constructed last year, yet it is large enough to cause some concern and should call attention to the necessity for more careful construction and the use of better materials in the future.

With the possible exception of two of the structures which have been rejected, they will be replaced or repaired at the expense of the contractors who constructed them. In justice to the contractors who have had work rejected it should be stated that they have shown a willingness to meet the recommendations of the Commission and to replace at their expense such work as is not in good condition.



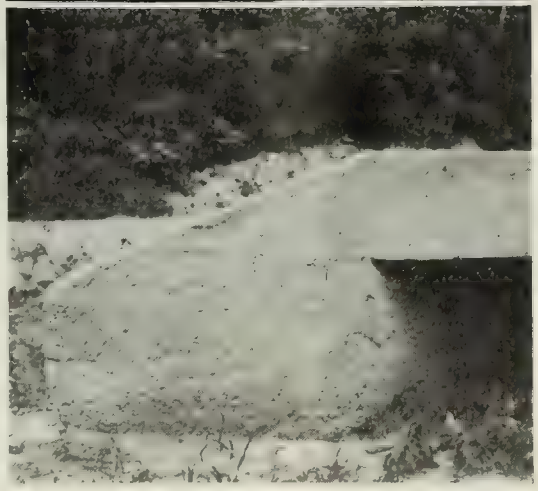


Fig. 1—Too Much Water Caused the Fine Particles of the Aggregate and the Inert Matter to Settle in a Layer the Full Length of This Wing Wall

A pick with one blow was thrust 8" into the solid body of this wing wall

Fig. 2—This Culvert Erected in Freezing Weather Was Not Properly Protected and the Concrete Was Frosted—the Frozen Material Will Have To Be Removed and Replaced With Good Material.

It is important to call to the attention of construction forces the necessity for more careful work in the future and the need of improving the quality of the work produced. Practically all of the poor construction is due to one of three causes: poor material, poor workmanship or insufficient inspection.

POOR MATERIAL

There are a number of contributing causes which add very greatly to the strength of the structure, and by a careful selection of the materials which compose the completed bridge much of the poor construction can be avoided.

It was noted in nearly all of the structures condemned that at least a portion of the cause for failure, and in most cases the entire failure, was the use of material which should have been rejected. In some cases gravel containing too high a percentage of clay was used and in others the sand was too fine and probably contained an excessive amount of vegetable matter or loam. Where crushed stone has been used as an aggregate, it was found in a few cases that the dust had not been screened out and this tended to weaken the concrete.

Dirty Water Responsible—Some of the most serious defects were undoubtedly caused by the use of water which was pumped from the stream while it carried considerable silt. Usually at some time during construction the creek water carries too great an amount of material in suspension. At such times the water supply should be obtained from other sources. It is absolutely essential that clear water free from silt, alkali or other harmful ingredients be used.

Ungraded Material—The grading of the material used in a structure will undoubtedly affect its strength and numerous instances were observed where little attention had been paid to this detail. At least one or two of the structures examined showed the presence of very fine material, with the cement content not properly increased to give sufficient strength to the concrete. In a few instances the failure could be traced to the use of poor cement, or it might be stated that the cement was a contributing cause to the failure. The indication of a large amount of fine material settling out on the top of the concrete at the end of a day's run would indicate that perhaps the cement contained too high a proportion of gypsum placed in the cement to retard the setting. Tests should be made on all of the cement used before it is hauled to the bridge site, and in case it does not pass the soundness test it should not be used until a long time test can be made to determine its acceptance or rejection.

POOR WORKMANSHIP

In almost every bridge or culvert condemned by the Commission it was found that one of the principal causes for the poor concrete was the lack of proper workmanship during the course of construction. This point might also be made on some work which has been accepted, and while the strength of the structures themselves is not impaired, their appearance has suffered materially from the lack of proper attention to construction details. It is absolutely essential that the concrete be properly mixed when it is placed in the forms. It is possible to affect the strength of the concrete very materially by leaving it in the mixer too long or by depositing it in the forms before thoroughly mixed. The proper amount of water to use must be determined largely by the aggregate used, but in any case when the concrete is placed in the forms it must be moist enough to spade easily and not so wet as to allow an appreciable amount of water to stand on top of the concrete after it sets. A mixture which will give a consistency as stated above is not hard to obtain and the water can be added so as to produce concrete of this kind with very little difficulty. Unless the inspector or the contractor's foreman watches this point carefully there is a tendency on the part of the workmen to add too much water, which will cause the fine particles of cement and inert matter in the aggregate to flow to the sides of the forms and be deposited there as laitance. You will observe in Fig. 1 that in the wing wall of an abutment which was rejected this fine material accumulated to a depth of 8″ and extended entirely through the wing itself and along the face of the wing for a distance of several feet. Defects of this kind are only due to carelessness and can easily be avoided by the proper precaution of removing this material before additional concrete is run. At the end of each day's run or before new concrete is deposited on the old, the entire surface of the concrete should be gone over with a brush and water and thoroughly cleaned. The forms should be wet several hours before concrete is placed and cleaned of all scale or mortar which may adhere to them. In the handling of the material from the mixer to the forms and after it is placed it is of great importance to see that the concrete is placed in approximately horizontal layers, and deposited at the place where it is to remain. The foreman should not be permitted to deposit concrete in larger masses and attempt to distribute it to the various parts of the structure by means of hoes. If this practice is followed the fine material which is held in suspension by the water will flow to the ends of the wings in the case of abutments or head walls on culverts and be deposited there, forming a chalky deposit. It has been necessary to reject a number of wings or to require expensive repairs on account of the lack of attention to this detail.

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[1] Asst. highway engr., State of Ia.

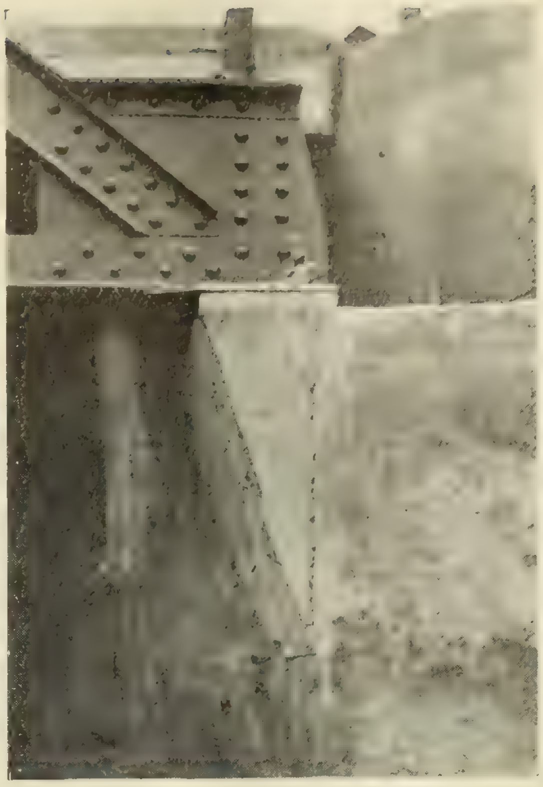

Fig. 3—The Abutments for This 50-ft. Steel Span Were Placed Too Far Apart

Note the method adopted by the contractor for securing a support for the bridge shoe—a solid pillar will have to be built up from the foundation and doweled to the abutment to make this support secure

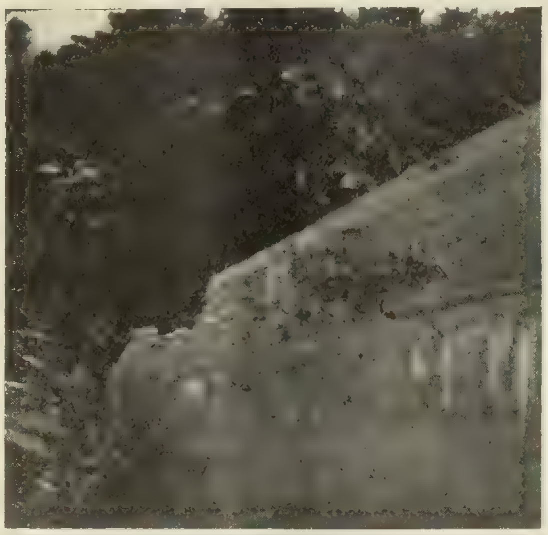

Fig. 4—At the End of This Wing Wall There Was a Collection of Large Stones With Not Enough Mortar To Fill the Voids.

The stones could be picked out with the bare hands

Fig. 5—This Bridge Will Have To Be Blown Out and Rebuilt

Frozen concrete, lack of cement, dirty material and crude workmanship—a coat of neat cement 1½″ thick in places had been plastered over this bridge

GOOD APPEARANCE EASILY OBTAINED

The appearance of the structure may be greatly improved by carefully spading the material after it is placed in the forms and by attention to see that the voids in the stone are entirely filled with mortar and that mortar is flushed to the face of the forms to present a smooth surface. Fig. 4 is an excellent example of where this provision was not carried out. The exposed surface can be further improved by careful form work and the filling up of all cracks which may appear in the form lumber and between the individual boards and by proper bracing to see that the forms do not bulge or get out of alignment before the concrete sets. Numerous cases may be cited where the lack of attention to proper form work has caused the appearance of the structure to be greatly damaged. Sharp corners in the forms should be avoided and triangular fillets placed at these points before the concrete is poured. It is also desirable to go over the entire structure immediately after the forms are removed and trim off such irregular corners or places as appear at that time. The use of a neat cement wash should not be permitted except in extreme cases, since it adds nothing to the strength of the bridge and detracts materially from the appearance.

FROZEN CONCRETE

In many cases frozen concrete was noted. The only remedy for conditions of this kind is to remove this material and replace it with new concrete. This year it will be the position of the Commission to stop all construction work Nov. 1, to prevent a re-occurrence of conditions of this kind.

SUPERVISION

More attention should be given to the methods of laying out the work in the field by the engineer and contractor. You will note in Fig. 3 that abutments for this 50-ft. steel span were placed too far apart, which necessitated the construction of additional bearing for the shoe. An attempt has been made by the contractor to meet this condition as illustrated and it is very evident that the repair is not acceptable.

Grading crews should be given instructions to take particular care in filling over bridges which have recently been constructed, since serious damage may result from the lack of proper care in placing filling material next to the new concrete. Wherever possible the filling should be placed in horizontal layers and each layer tamped before the next layer is placed upon it. Large chunks of frozen earth or large boulders dumped from the top of the fill and allowed to roll down against a wing wall or coping may seriously damage the structure. It is a good practice to place wooden poles or old fence posts in a vertical position against the wing walls at the time of filling, allowing the tops of these posts to extend above the top of the wing and thus protect it from severe blows which may result from improper filling. These poles should be removed before the filling is completed and the material filled in behind the wing wall to within a small distance of the top of the wing wall itself.

The third cause for the rejection of some of the work done in the past few months can be traced directly to the lack of inspection on the part of the engineer. Where the structure has failed because of poor foundations, or, as in one instance, where the bridge was built several feet above the point indicated as the bottom of footings on the plan, the failure can be directly charged to the engineers themselves. The specifications provide that the contractor shall notify the engineer before concrete is run in the footings and the engineer or one of his assistants should make it a point to inspect every foundation before any concrete is placed. Bench marks should be established at all bridge sites when the original field notes are taken. If necessary, levels should be taken to determine that the footing has been carried to a depth as shown on the plans and for all structures of importance soundings should be made to determine the character of the foundation material. It is needless to go into detail as to the necessity for proper foundations for concrete structures, but it appears that this important feature of the work has been overlooked or neglected by some of the engineers in the performance of their duties. As stated above, there can be no excuse for conditions of this kind and the responsibility for failures due to the lack of proper foundation must lie with the engineering force when this work is under their supervision. Where any doubt exists as to the foundation material below the bottom of the footing piling should be driven, as this is the cheapest insurance possible to prevent failure due to the deepening of the stream bed or the changing of a stream course. A good rule to follow in all cases is to drive piling wherever possible. Center line and reference stakes should be placed on all bridges of any size and the contractor's foreman instructed that the work must be carried out in accordance with these stakes. At frequent intervals during construction the engineer should check up the forms and alignment to determine that they are being constructed as staked out. Often the contractor's representative does not have means for checking up the larger bridge work and it is the engineer's duty to see that the work is either constructed in accordance with the plans or the work stopped before it proceeds beyond the point where any defects cannot be readily remedied. Inspectors should be provided for all important work and given instructions to keep a complete inspection record of all the important operations attending the construction of the bridge. This is essential on all work of any size and as a policy cannot be disputed where competent inspectors are provided. A county does not relieve the contractor from any responsibility by placing an inspector upon the work, but rather protects itself against poor workmanship or the use of poor materials the quality of which cannot be easily determined after they are placed in the structure.

It may appear that the details mentioned are of minor importance and recognized by every one doing concrete construction work, yet the failure of $20,000 worth of bridge construction can be traced directly to failure to observe the minor details mentioned above. This is too high a price to pay for careless construction or the lack of proper care in the selection of materials, and it should be recognized at once by the contractors and county forces that more care must be taken in the future to secure better construction with a more desirable surface appearance. This Commission will insist on a more rigid compliance of the provisions of the specifications in the future than in the past. Work which is constructed by contract in an unworkmanlike manner will be rejected and must be replaced at the contractor's expense. As stated above, the responsibility for poor alignment, poor foundations or improper design is not the fault of the contractor entirely, but such responsibility must be shouldered by the men who are in direct charge of the work during its construction.

A Grape Arbor with Concrete Arches in Two Pieces

A grape arbor with concrete arches to support the wire netting is shown in the accompanying illustrations.

The top of the arch is 7′ high and the width is 7′ at the base. The arches are in two pieces, joined in the center at the top. Each unit is set 2′ in the ground, making the extreme height 9′. The molds in which the half-arch units were made as shown in Fig. 2. The wood spacers used to keep the sheet metal form in shape are removed as the mold is filled. Each unit is 6″ x 6″ at the base and tapers to 5″ x 5″ at the end, which becomes the center of the arch when erected. A 1:3 mix of cement and sand was used, and reinforcement is provided in four No. 9 wires. When set up the arches were secured in position by a 1½-in. iron pipe running the entire length of the arbor just above the center. The arches are fastened to the iron straps which are bolted into the concrete on each side of the pipe, provision having been made for bolting when the units were cast. This information is from C. J. Ballou, Delphos, Kans., who built the arbor.

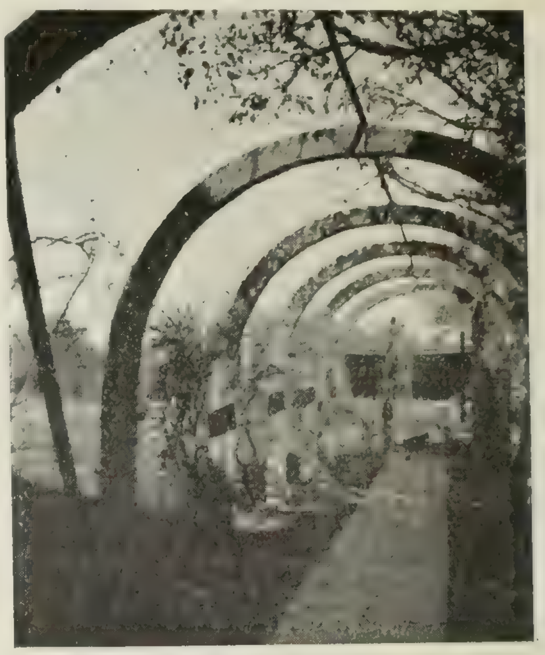

Fig. 1—Grape Arbor with Concrete Arches

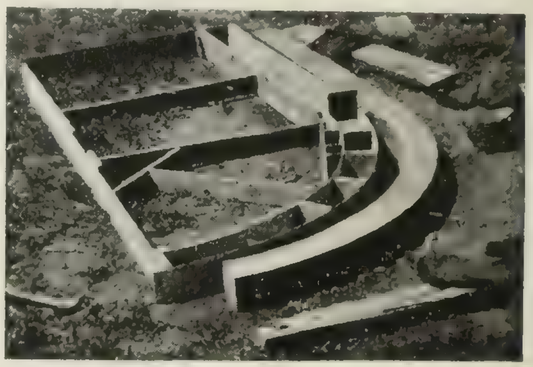

Fig. 2—Mold in Which Arches Were Made—One Just Removed From Mold

Field Methods in Concrete Construction—Arch Centers: Design and Construction

By Jerome Cochran, C. E.[1]

The series of articles on field methods in concrete construction, of which this is the seventh, has been planned in opposition to the general assumption on the part of writers that standards or methods of construction have been established long ago and have become common knowledge. The first article on "Selection of Concrete Materials" appeared in this magazine for Jan., 1915; the second article on "Proportioning and Mixing Concrete" appeared in Feb., 1915; the third article on "Design and Construction of Forms in General" appeared in Mar., 1915; the fourth article on "Column Forms" appeared in Apr., 1915; the fifth article on "Beam and Slab Forms" appeared in June, 1915; and the sixth article on "Wall Forms" appeared in July, 1915. The following article relates to the fabrication and the erection of arch centers, with special reference to concrete arch bridges. The four previous articles on form work should be carefully studied in conection with this article. The author has drawn liberally on his book, Inspection of Concrete Construction.[2]

INTRODUCTION

Success in concrete arch construction depends nearly or quite as much on the centers, necessary to shape and support the structure without any possibility of the lagging sinking or sagging when the concrete is being put in place or before it has set, as it does on the design and construction of the abutments, piers, and arch ring. The problem of center construction is, therefore, twofold, i. e., (1) building a structure which will remain as nearly as possible invariable in level and form from the time it is made ready for the concrete until it is removed from underneath the arch, and (2) when the time for removal comes, the construction must be such that the operation can be performed with ease and without shock or jar to the masonry.

In general design and construction the centering employed for a concrete arch is similar to that used for a masonry arch or stone bridge, and for equal loads the same rules and practice serve for both. There is this essential difference, however, between centers for concrete arches and masonry arches: in the former the lagging must be made smooth so as to give the exact shape to the concrete and so constructed that the concrete will not adhere to it. Centers for concrete arches not only serve as molds for shaping the soffit of the arch ring, but as a support for the forms for molding the arch-ring face and the spandrel walls. The spandrel, together with face wall centering, may be built in place at the same time the arch ring concreting is put in place. The vertical timbers supporting the lagging may be tied together at the top by cross-ties.

The general subject of centers is treated in considerable detail in a work by John B. McMaster, entitled *Bridge and Tunnel Centers,* Van Nostrand's Science Series, published by D. Van Nostrand Co., N. Y. C. It is also treated in such works as Buel & Hill's *Reinforced Concrete,* Gillete & Hill's *Concrete Construction—Methods and Costs,* and Taylor & Thompson's *A Treatise on Concrete—Plain and Reinforced.* The inspection of forms, molds, centering and falsework is considered in the writer's work on *A Treatise on the Inspection of Concrete Construction,* pp. 197-225. The drawings of arch centers shown in the leading technical journals or encyclopedias of engineering can be modified in general and in detail according to the conditions governing the design and construction of the arch under consideration, as well as those given in the works mentioned.

CLASSES OF CENTERING

Arch centering in general may be divided into two classes, i. e., (1) those which are supported at every intersection of the braces or web members with the lower chord or tie-beam, and (2) those which act as a truss in spanning an opening to give under clearance. There is no distinctive division between the two classes.

In the first class, struts or braces support the timbers or ribs carrying the lagging at every joint. These struts or posts are braced together to form transverse bents, which are spaced at convenient distances apart along the axis of the arch and braced longitudinally. The supports can be arranged in any way that judgment and economy dictate.

In the second form, trusses are employed. These trusses may carry the lagging directly, in which case they must conform to the curve of the intrados of the arch, or they may support short braces which in turn support the ribs. These trusses may be carried on bents or masonry supports at the ends. Centers of this class are called "retroussée" or "cocket" centers.

A European practice which has not gained recognition in this country and which would seem to be of doubtful expediency under all ordinary conditions, or impractical for most forms of arch-reinforcement, like the Monier, Thacher, Hennebique, etc., consists in carrying a portion or all of the weight of the center and its load of concrete by suspension from the exceptionally strong reinforcing ribs used in certain forms of concrete arches, without the use of centers or temporary supports. With such a scheme, deformations are very likely to take place continually during construction, and would consequently have an injurious effect on the arch ring, the amount of which could not be estimated. The writer considers this system of construction as experimental and even hazardous when applied to large or important arch bridges, although it is used successfully on a small scale for instance, in floor construction.

The type of centers to be used in any case will depend entirely upon local conditions. Where the restriction of the opening is of little or no importance, bents would probably be the most economical and satisfactory. In other cases, where it is desirable to obstruct the opening as little as possible or to keep traffic open under the arch during construction, the trussed form of centering would probably be best adapted. The width of the span may be only a narrow opening or series of openings, or it may be equal to the span of the arch, with the centers supported by the abutments or piers.

RIGIDITY OF ARCH CENTERS

Arch centers should be thoroughly braced or tied together so that the pressure of the concrete, or the movement of men, machinery or materials, will not throw them out of place. It is essential that they be of such rigidity or strength that the arch will not be stressed in the slightest degree before the concrete attains a perfect set; otherwise any deformation of the centers due to insufficient strength or improper bracing will cause a corresponding change in the intrados of the arch, and consequently in the line of resistance, and may endanger the whole structure. A great deal of bridge work is badly marred by the lack of rigidity in the centers, and for this reason it is important that the supports and centers be well braced in all directions, and so rigid that they will not easily warp and twist.

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[1] Cons. engr., Houston, Tex.

[2] Myron C. Clark Pub. Co., Chicago

CAMBERING ARCH CENTERS

In centers there is some movement due to the adjustment of the wedges under load and the compression of the lumber, so that the rise of the centering should be made slightly greater than the rise designed for the arch, in order that after deflection the arch may be of the desired curvature. By raising the crowns of the centers above the intended height of the finished arch, an allowance is made for settling when the centers are being loaded and when struck, since timber is not absolutely rigid or incompressible.

Care must be taken to avoid excessive and injurious deflections in arch centers, under the changes in the loading that will occur during construction. By properly designing the centers, deflection can be reduced to a minimum, while deformations during the progress of construction of the ring can be to some extent prevented by temporarily loading the centers at the crown with materials of construction or other means, and gradually removing the temporary load as the weight of the ring comes on the centers.

The camber given to centers should be about equal to the deflection of the arch ring under full loading, so that the ring will never have a length, measured on the neutral surface, shorter than that assumed in the computations of the stresses and sections. The probable deflection in arch centers may be calculated by using the usual formula for deflection, which may be obtained from any work on mechanics.

The camber may be assumed equal in amount from 1/1,000 to 1/500 of the span, and will generally answer for most purposes where trussed centering is used. Some engineers provide for an additional rise in the centering of 1/800 of the span, while others assume from 1/1,200 to 1/600 of the radius at the crown. Still others make an allowance for settlement equal to $\frac{3}{4}''$ for each 30′ vertical height.

ARCH RIBS OR CENTER FRAMES

The ribs upon which the lagging rests directly are usually formed by spiking together several planks so as to break joints, the top edges of which are cut to curve parallel with the intrados and the thickness of the lagging below or inside of it, so that the top of the lagging will coincide with the intrados. Steel shapes bent to the desired curvature are sometimes used. Two-in. plank sized to $1\frac{1}{4}''$ are often used for lagging, with the supporting ribs spaced from 3′ to 4′ o. c. While it is customary for the arch ribs to be covered with narrow planks running parallel with the axis of the arch, sometimes transverse timbers spaced 1′ or more apart are placed on top of the ribs and a tight longitudinal floor of tongue-and-grooved flooring used to form the lagging.

A braced wooden rib with one center support and two end supports is generally used for spans up to 40′ or 50′, but for longer spans a trussed center with support from 10′ to 20′ apart is employed.

BOLTING CENTERS

Little or no dependence is usually placed in nails when constructing centers for arches of more than 30-ft span, except for fastening the lagging, for securing the wedges, and for a few minor details, as all main members are generally bolted together at joints.

LAGGING FOR SOFFIT-MOLD

The only means usually employed for securing a smooth soffit-mold in constructing plain concrete arches, consists in using either smoothly dressed lagging or by giving the lagging a smooth surface by a suitable covering. All the purposes of a special covering, and usually at a cost which is no greater, may generally be accomplished by using a smoothly dressed and perfectly fitted lagging. When conditions render necessary the use of undressed lagging-timber a plastering of wet clay, or of mortar covered with thick paper or with cloth, may be used. These materials, in some instances, have been found to give a satisfactory covering.

The lagging should be surfaced or dressed on the upper side, of uniform thickness and suitable width, and of selected material, and the edges surfaced so as to form tight joints when put in place, the object being to obtain a smooth surface on the soffit of the arch. As previously mentioned, 2-in. plank sized to $1\frac{3}{4}''$ on usually employed for lagging, the supporting ribs being placed from 3′ to 4′ apart, and the lagging laid with radial joints parallel to the arch axis. The ends of the planks should be neatly butted against each other, without crevices or offsets between the sides or ends of adjacent planks.

A very convenient form of lagging for concrete arches has been found to be 2-in. x 4-in. pieces set on edge, being narrow enough to conform to the curve of the ring, and deep enough to carry the weight of the ring between the ribs when the latter are placed from 5′ to 6′ o. c. The deflection will not be enough to give an uneven surface to the soffit of the arch. If lightly toe-nailed at not more than two or three places, the salvage will more than pay for the extra material, and fewer costly ribs are required, as the latter can be spaced further apart than when thin lagging is used.

The lagging for the center may be in two thicknesses, but the top layer should preferably be tongue-and-grooved lumber, and the lower layer should be dressed to match the top surface when in place.

Lagging should have a deflection under the full load of the arch of not more than $\frac{1}{8}''$. With thin lagging care must be taken to prevent deflection.

The deflection of the lagging and other beam supports may be investigated by the formula

$$D=5\ Wl^3 \div 384\ EI,$$

in which D is the deflection in inchts, W the weight in pounds uniformly distributed, l the length of the span from center to center of supports in inches, E the coefficient or modulus of elasticity of the timber, and I the moment of inertia of the cross-section in inches. E may be taken at 1,200,000 for white pine and spruce and at 1,600,000 for yellow pine or oak.

The lagging is sometimes covered with building paper of a strong and durable character, lapped 1″ at joints and tacked in place, but the use of paper needs constant attention in order to secure satisfactory results. It is somewhat difficult to keep the paper absolutely smooth, so that the final surface does not show wrinkles, although this may not be of much importance in most arches. The paper, however, is easily torn in placing reinforcement. Unless the paper is very oily it will adhere to the concrete, necessitating that it be burned off so as to effect its removal, as a thorough soaking very seldom removes the paper entirely.

STRIKING ARCH CENTERS

To facilitate striking or lowering the centers without injuring the surface of the concrete and without straining the arch, they should be supported on folding wedges, sand-boxes or jackscrews. By such devices the centers may be struck, or lowered, uniformly, slowly and without shock. Centers in all cases must be dropped away from the arch readily, and let down or relieved of their load gradually. In fact, ease of removal is a requisite of an arch center second only to its strength and stability, and the provisions for striking centers for concrete arches should be equal to those for stone-arch centers.

WEDGES

The wedges usually consist of a pair of folding wedges (with the outside surfaces of the two wedges parallel) from 1′ to 2′ long and about 6″ wide, preferably of oak or other hard wood, having a slight taper. When placed at or near the top, the wedges should not be loaded with more than 30,000 lbs. per wedge. At the bottom they should not be loaded to more than 40,000 lbs. In no case should the pressure exceed 300 lbs. per sq. in.

The wedges should have a very slight taper of from 1:5 to 1:10, preferably the former, as it is necessary to remove the centers slowly, especially for large arches. The taper should vary with the span of the arch; the longer the span, the less the taper. The grain of wedges should run with the slope, and their contact faces should be planed true and smooth for their entire width and length.

To lower the centers equally the wedges should be driven back uniformly, in order to avoid unnecessary jar and vibration. To facilitate this, the wedges should be lubricated.

SAND-BOXES

The centers may be provided with sand-boxes, consisting of a steel cylinder in which sand is confined, with a wooden plunger resting on the sand, and the centering of the arch carried on these wooden plungers. A plug at the bottom of the cylinder regulates the outflow of the sand, and may be withdrawn and replaced at pleasure. The centers are lowered by allowing the sand to escape through the hole at the bottom of the cylinder or box, as the case may be, and the amount of this lowering can be readily controlled by the amount of sand allowed to escape. Sand-boxes, when they work as they are supposed to work, allow a very gradual and uniform lowering of the center.

In using sand-boxes particular care should be exercised, first, to secure a proper sand and, second, to exclude all foreign material from the boxes, which must also be properly sealed, preferably with cement mortar around the plunger, to prevent the entrance of foreign matter. A good quality of sand should be secured for use in the boxes. It should be thoroughly washed, to remove all silt, and thoroughly dried before using. A poor quality of sand for use in sand-boxes has caused trouble on several occasions, as well as the failure to seal them around the plungers.

Sand-boxes sometimes fail to operate perfectly when it comes to lowering the centers because of the packing of the sand, due to wetting with silt-bearing water, or to dirt or cement finding its way into the box. Particular care must therefore be employed when sand-boxes are used, for if any foreign substance is allowed to enter them, or if they are not properly sealed, trouble may be experienced, either in their settling too soon or failure to settle at the proper time. The careful sealing of the boxes against the entrance of foreign matter, and their frequent inspection, are obvious precautions against trouble from this source. It cannot be too strongly emphasized that care must be taken to keep the sand dry during the entire construction of the arch and so that it will run when the boxes are tapped. The sand in these boxes must be thoroughly packed to prevent settlement of the concrete before setting.

Where any of the above precautions are disregarded, trouble is likely to be experienced either through the sand flowing prematurely or its failure to flow at the proper time. Sand is not entirely incompressible, and several cases might be cited in which serious trouble arose from the compressibility of the sand-cushions used to carry the centers.

FOUNDATIONS

In order that the supports for the centers be as unyielding as possible, it is essential that substantial foundations be provided; otherwise the centers are likely to be warped or twisted during the process of concreting the arch.

If the sub-soil is sufficiently firm, i. e., bed rock or an equally good foundation, sills may be put down, and the bents or struts rested directly on them, but in poorer soil temporary masonry or pile foundations should be provided. If piles are used they should be driven to a firm bearing in a manner similar to permanent foundation piles, so that no settlement will occur when the weight of the structure is brought upon them. Concrete foundations are usually to be preferred, being of such size as will not permit a settlement greater than 3/16″ under the maximum loads they are designed to carry.

FORMS FOR SECTIONS OF ARCH RING

Suitable forms should be constructed to hold in place sections of arch rings being concreted. If the concreting is done in transverse sections, the forms should be set in radial planes and straight across the arch at right angles to the face. If the concreting is done in longitudinal sections, the forms should be set vertical and parallel with the face of the arch.

The statements made in the third article of this series on "Design and Construction of Forms in General," published in Mar., 1915, apply with equal force to the fabrication and erection of forms for concreting sections of the arch ring, to which the reader is referred.

SPANDREL WALL FORMS

For spandrel wall forms it is necessary to make a form for each side and to hold the forms together by bolts or strong wires so spaced as to prevent any distortion. Such forms may also be held apart with concrete or wooden separators which can be easily removed as the work progresses, or which, in the case of concrete separators, may be incorporated in the concrete without injury to it.

The sixth article of this series on "Wall Forms," published in July, 1915, takes up in considerable detail the fabrication and erection of spandrel wall forms, and should be carefully studied.

The difficulties which arise in the fabrication and erection of forms for spandrel walls are due chiefly to the necessity of providing panels, molding and other architectural embellishment in the front face and to the unsatisfactory conditions for bracing the face-lagging strongly in place. The bracing of the rear wall forms may be accomplished by a cross-sill between the bottoms of opposite studs and by diagonals from this sill to the top and middle of the studs. The main point is to secure an unyielding support for the lagging, and particularly for the lagging for the front face. To do this the studs should not be spaced more than 5′ apart and should be strongly braced and tied in position, and the lagging should be heavy enough not to bend between studs; lagging from 2″ to

3″ thick is just about the right size, being none too heavy.

Lagging for the face wall must be smoothly dressed and tightly jointed, while that for the rear can be made of rough boards. That for the former should invariably be fastened to the studding in perfectly horizontal lines. The ends of these planks should be neatly butted against each other, and the inner surface of the form should be as nearly as possible perfectly smooth, without crevices or offsets between the sides or ends of adjacent planks.

The face wall form has also to carry the attached panels and molding or other ornamental forms, thus calling for special design and construction. Molding ornaments in place should generally be confined to belt courses, copings, plain panels, etc. Bridge railings can be and usually are made up of separately molded posts, balusters, bases and rail. Such ornamental work as medallions, moldings, panels, rosettes, statuary, etc., can be similarly molded and placed in the structure as the monolithic work reaches the proper point.

A negative of the ornamentation called for by the plans is constructed on the lagging, and it may be simple or complex according to the amount and character of ornamentation desired. The molds may be made of wood, iron, sheet metal, sand, plaster of Paris, glue, etc., being divided into sections that will part from the concrete surface without the least friction or adhesion. They should have ample strength and rigidity to withstand tamping and other strains without distortion, and so constructed as to be easily operated with perfect results without the use of unusual skill. Sectional molds should be carefully fitted and should be equipped with locking and squaring devices.

For most kinds of ornament, such as newels, finials, rails, balusters, spinels, balls, caps and bases for piers, etc., the forms may be constructed of wood, iron or sheet metal, but where rosettes, medallions, scrolls, or similar complex forms are called for it is often preferable to make negatives in plaster of Paris from clay models and set these negatives in the lagging at the proper places.

Ornamental concrete work produced from sand molds, requiring merely a wooden model or pattern and iron-molders' sand, does not as a general rule craze or develop checks, cracks, or map-crazing—an advantage of considerable importance where dependence is placed upon surface finish for its appearance.

Plaster molds, made from wood fiber plaster, wall plaster, gelatin or other patterns, are particularly adapted to fine-line and under-cut ornaments. They must have a coating of shellac, glue, oil paint or other waterproof coating, owing to their porosity, and the mold should be oiled each time before making the cast. After the concrete has set, the plaster is broken or chiseled away, leaving the cast exposed.

Ornamental concrete work with fine lines and considerable under-cut may be cast in glue molds, which should have an oil coating before each cast is made. Glue molds are made by placing the model or pattern upon a molding bed or board and coating it with modeling clay to the thickness desired for the glue mold, the model having been previously oiled or otherwise treated to prevent the clay from adhering. A plaster shell is then built over the clay coating, and removed as soon as it has hardened. After removing the clay from around the model, melted glue is poured into the space left between the plaster shell and the model, the plaster shell being pierced at the highest point for inserting a funnel for pouring the glue, and at several other places to permit the steam from the hot glue to escape. As soon as the glue has been allowed to harden, the plaster shell and glue mold can be removed from the model.

Ornaments may also be cast on the faces of concrete block which are molded separately and set into the concrete wall as the work progresses.

WORKMANSHIP

Arch centers should be constructed by experienced and capable workmen only, and must be of first-class workmanship equal to the best class of heavy timber work. Defective workmanship upon arch centers means not only unsafe work but unsightly work as well. All saw cuts should be true and surfaces of abutting timbers adzed off to make a snug fit. The centers should be fabricated, put up and removed in a manner satisfactory to the engineer.

ADHESION OF CONCRETE TO LAGGING

Care should be taken to prevent the concrete from sticking to the laggin; otherwise, it would mar the smoothness of the finish of the arch and might cause difficulty in removing the centers. To prevent the concrete from adhering and to obtain a smooth surface, the lagging should be dressed smooth and thoroughly wetted, soaped or oiled before concreting. The lagging may be covered with cloth, paper or a layer of clay as previously mentioned. It is found, however, that there is very little likelihood that the concrete will adhere to the lagging where centering is to remain in place for a long period.

GROINED ARCH CENTERS

Forms or centers for groined arches, built so that each section covers the space, square in plan, between four piers, should be so designed as to take the thrust of the adjacent completed arches, and if sufficient forms are not built to cover the entire reservoir, and thus transmit the thrust to the walls, the piers at the border of the forms must be thoroughly braced to the opposite side walls, or the piers will be toppled over and the roof wrenched. Care must be taken to make a neat fit along the valley of the forms or centers for groined arches, extending diagonally between piers, in order to avoid a sharp corner on the finished concrete. Imperfections in the joints may be improved by fitting a small fillet into this valley.

CONDUIT CENTERS

The principal requisites of centers for conduits, culverts, etc., are similar to those given at the beginning of this article for arch centers, with the exception that they should be so constructed that they can be readily assembled and taken down and thus used over and over for succeeding lengths of conduit.

Representative examples and methods of constructing forms and centers for conduits are given in Buel & Hill's *Reinforced Concrete,* Gillette & Hill's *Concrete Construction —Methods and Costs,* and Taylor & Thompson's *A Treatise on Concrete —Plain and Reinforced.*

"Concrete Shoes"

Portland cement appears to be useful to about every industry, but it is interesting to find that it is employed as the principle agent in a patented process for strengthening, waterproofing and weighting sole leather. The recipe reads as follows:

> Ordinary sole leather is soaked in water until thoroughly pliant. It is allowed to become half dry and given a coat of boiled linseed oil on the grain side. A bath is prepared of Portland cement 8 oz., borax 2 oz., and cold water to consistency of milk; to each pound of leather is allowed one-half pound of cement and borax. The leather is allowed to stay in this bath 24 hrs., and is tested by cutting its edge; if not saturated it is allowed to stay longer. The longer it stays the heavier and firmer it becomes. At the proper consistency it is allowed to dry and is oiled with linseed oil.

This process is said to increase the durability 100% to 200%, and the leather is made more nearly waterproof. It is said to be equally efficacious applied to finished leather or leather in process of tanning.

Reinforcing and Sub-Grade Drainage to Eliminate Cracking in Concrete Roads

In view of the fact that the New York State Commr. of Highways is reinforcing concrete roads when constructed on clay sub-soil[1] and also in view of the recommendation of W. A. McIntyre, Chf. Road Engr., of the Assn. of Am. Portland Cement Mfrs., that "reinforcement be placed on roads 20′ or more in width and on narrow roads where there is doubt of drainage and stability of sub-base,"[1] there is special interest in comment by John W. Mueller[2] on reinforcing narrow concrete roads and by Andrew M. Lovis[3] on drainage of the sub-grade to avoid the consequence of frost action. Mr. Mueller said:

The subject of reinforcing concrete street pavements has already been thoroughly discussed. As evidence of this, reference may be made to the meeting of the National Conference on Concrete Road Building in Feb., 1914. At that meeting practically every committee report referred to the necessity of reinforcing concrete pavements and roads, some advocating the practice to a greater extent than others on account of the particular subjects treated; for example, the Committee on "Thickness, Crown and Grades" reported that pavements on clay soil should be reinforced with ¼ to ½ lb. per sq. ft. of pavement while the Committee on "Contraction and Expansion" reported extensively on the value of reinforcement in preventing cracks and the Committee on "Reinforcing for Concrete Roads" stated as follows:

> This committee is of the opinion that all concrete highways should be reinforced with a fabricated reinforcement and undoubtedly, regardless of width, a reinforced concrete roadway is superior to any other form of road.

The Conference as a whole said "when in doubt reinforce the pavement," and adopted as one of the details of recommended practice under the subject of "Reinforcing" as follows:

> The Conference is of the opinion that all roads exceeding 20′ in width should preferably be reinforced with some form of metal fabric, etc.

The meeting of the American Concrete Institute at its annual convention in Feb., 1914, tentatively adopted Standard Specifications for Concrete Roads and Pavements containing the following:

> Concrete pavements 20′ and over in width shall be reinforced with metal fabric, etc.

The reports of the several committees and the discussions at these two very important meetings held last year, resulted in advising the use of suitable fabricated steel reinforcements in all pavements 20′ or more in width; as a result reinforcement has been recommended for pavements which generally are classed as city streets.

Since wide pavements have been very carefully treated, and engineers are rapidly coming to the conclusion that these pavements must be reinforced, this paper will be devoted to concrete roadways narrower than 20′. In narrow roadways when reinforcement has not been used, cracks appear, and are objectionable, and should therefore be eliminated.

The primary reason why reinforcement is used, or should be used in narrow as well as wide pavements is to eliminate or reduce to a minimum all cracks. The conditions causing cracks may be divided under several headings.

1. Uncertain Foundations.
2. Changes in Moisture Content.
3. Change during setting period.
4. Temperature changes.
5. Thickness of pavement.
6. Length of slab.
7. Irregular surface of sub-grade.

Under the heading "Uncertain Foundations" may be classed such conditions as fresh fills, wet cuts, undrained roadways, soils of boggy nature and pavements built over an old roadbed of a lesser width than the new pavement.

It is practically impossible properly to compact filled ground and prevent all settlement. Experience tends to show that poor results are often obtained when pavements are laid on fresh cuts or fills. In the majority of cases, new concrete pavements when laid on country roads are placed over an old crushed stone or gravel roadbed that is narrower than the new work and even though the old bed be loosened to a depth of 6″ to 9″ and rerolled it is practically impossible to secure a finished sub-grade which is safe against settlement or some shrinkage.

In the spring of the year when the side ditches are almost always filled with melting snow or water a great amount of moisture finds its way through the gravel or crushed stone berm at each side of the roadbed and then into the soil under the pavement. The presence of this moisture produces expansion and the best of summer brings the drying out process which results in contraction. The movement of the soil under the pavement is both vertical and horizontal under such conditions, the magnitude of the movement being governed by the nature of the soil and the variation in temperature.

It has been found, even when foundations have been given special attention in the way of draining off all surface water, that it is practically impossible to prevent the soil from absorbing some moisture, with a possible consequence of some vertical movement.

Changes in temperature and the moisture content produce a movement of the concrete slab and if this slab does not have sufficient strength to allow such movement, cracks must form. This condition is more dangerous with relatively thin slabs, and where there is a distance between transverse expansion joints of 50′ or more.

Investigations made by the Office of Public Roads U. S. Dept. of Agriculture and at the University of Michigan by White and the Boonton Dam Experiments, Tran. of A. S. C. E. Vol. LXIII, 1909, on "Moisture Content" and in dimensional change in concrete during the hardening process, show results which amount to a maximum contraction for 1:2:4 concrete for 6 mos. of 0.00068 in. per in. of length, a figure which goes far toward accounting for many cracks in concrete work, where reinforcing has not been used.

The change in dimension during the hardening process thus amounts to approximately .13″ for a pavement 16′ in width and .41″ for a pavement slab which is 50′ in length. Added to this difference in dimensions is that which is due to temperature changes.

We all know that it is practically impossible to bring a sub-grade to a smooth and perfect surface, and keep it in smooth condition until the concrete has been deposited. The sprinkling of the surface just before placing concrete is often necessary in order to keep the mortar from being drawn out by the dry sub-grade. During the process of sprinkling it is very easy to get a mud which may increase the irregularities over the area to be concreted.. These depressions and variations of the sub-grade offer added resistance to the free horizontal movement of the pavement slab when going through the changes in dimension as resulting from the hardening process and temperature changes.

It has been the general practice in the past to construct narrow country roads without the use of reinforcement or any other means for preventing cracks except the use of transverse expansion joints placed from 25′ to 35′ apart. Cracks that form in the slab have been filled with a tar or an asphalt preparation or in some cases neglected entirely.

There are many good reasons why such practice is objectionable. Cracks in the slab weaken it as a wearing surface and in time a partial disintegration results. These cracks require repairs in increasing amounts. The disagreeable appearance of such a pavement is unnecessary and does discourage taxpayers in that district from making further use of concrete as a wearing surface.

Another objection to this method, especially for small road systems is the lack of the necessary organization and equipment for proper attention to these repairs. In other words the cracks will not be properly taken care of and the pavement will naturally suffer thereby.

Reports prepared after careful examinations by officials connected with the largest systems of county road construction in the country, that out of over 6,000 125-ft. sections varying from 1 yr. to 4 yrs. in age, show that at the time of examination nearly 23% of the sections were defective, owing to cracks of various kinds.[4] About 15% showed longitudinal cracks, 5.3% transverse, and 2.4% diagonal. One road over 3 yrs. old had 60% of the sections cracked, no reinforcement being used in this work. Although it is possible to repair these cracks with tar or asphalt so that for the present at least they appear to be giving excellent service, it is fair to assume that these necessary repairs will increase with the age of the pavement, and time alone will tell positively whether or not such methods were economical.

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[1] See CONCRETE, July, 1915, Vol. 7, p. 39

[2] Cons. engr., Newcastle, Ind., in a paper presented at the 1915 convention of the Am. Concrete Institute

[3] 1st asst. engr., Mass. Highway Comm., Boston, in a paper presented at the 1915 convention of the Am. Concrete Institute

[4] See CONCRETE, Jan., 1915, p. 96

By the use of suitable reinforcement to prevent these cracks, we have at a small additional cost secured a road of a much higher quality and one that will not require such constant attention to repairs.

The great demand for a reduction in the maintenance cost of our country roads has been very successfully met in many localities by adopting concrete as a wearing surface. The results have been very satisfactory, except in such cases as have been found, where the engineer endeavors to reduce the cost of the work by neglecting in his specifications the quality of aggregate, the proper preparation of the sub-grade or the elimination of reinforcement.

Reinforcement suitable for narrow country roadways can be purchased for from 6 cts. to 8 cts. per sq. yd. and considering the small additional first cost and advantage gained by the use of reinforcement in narrow concrete roadways, this type of construction is justified.

With expansion joints 25′ or 30′ apart, experience shows that from 50% to 75% of the cracks that form in plain pavements are longitudinal and undoubtedly formed by vertical movement of some portion of the slab. Experience also shows that the reinforcement should be placed near the top of the slab to take care of these conditions in the best manner.

Where the foundation is questionable and satisfactory drainage is impossible it would be good practice to use reinforcement in the bottom of the slab also.

Because of the impossibility of determining the true direction or location of the greatest stress or the foundation conditions which may govern, it unquestionably is preferable to use a reinforcement giving best possible distribution of the steel. In other words the reinforcement should preferably have small members with close spacing. There is also a decided advantage in using a reinforcement having high elastic limit and tensile strength, as the steel in actual practice will be subjected to very high stresses.

In roadways 14′ and 16′ wide, the writer has used a steel mesh giving an area of approximately .05 sq. in. per lin. ft. of slab in the transverse direction and .04 sq. in. in the longitudinal direction, with very satisfactory results. Various rules or theories for the selection of the proper amount of steel have been advanced with great confidence by several engineers and even with different methods of calculating they have all arrived at the same results. It is quite clear that reinforcement distributes the stress over the slab and if it is used in sufficient amount should prevent the cracks which are so objectionable to the wearing surface. It seems impossible to determine theoretically the exact amount of steel; therefore experience and experiments are the best guides.

If we as engineers intend to treat concrete pavements with the same degree of fairness as when using any other paving material, it will be necessary to give due consideration to the conditions which require the use of reinforcement. Concrete pavements for country roads will have a great future when a standard for this type of construction is perfected and adopted.

Mr. Lovis's paper follows:

There are four distinct features to be considered in road construction: the alignment, the grade, the foundation and the surface. We sometimes hear comparisons made of the relative value of these factors, but in the consideration of what is sometimes called "a perfectly good road" we will find that all are necessary and equally important. In order of their construction, the value of each depends upon the integrity of the preceding work. Almost an infinite variety of surfaces may be used on roads, and some variations may be made in the locations and grades, but whatever may be the alignment, grade or surface, we must try to make permanent the foundations.

There has been a belief that the foundations under a concrete road may be neglected, and in fact it has been believed that concrete may be laid with perfect safety on almost any kind of soil without danger of bad effects from the frost action. There have, however, been many experiences which prove that such is not the truth, and most concrete roadbuilders are now of the opinion that the sub-grade is to be constructed quite as carefully for concrete as for a macadam or a gravel surface, and this is substantially the opinion of the Committee on Sub-grades as expressed in its report at the National Conference in Chicago last year.

It will be found very difficult to make any standard specifications for sub-grading which will not be a source of danger, rather than of safety, in practice, the danger being that the inexperienced engineer may follow literally the rule given, though the physical conditions require special treatment. The construction of the sub-grade for a macadam or gravel road has always required more special experience on the part of the engineer than any other subject connected with the work, after the location and grade lines have been determined. In Massachusetts, we have learned something of this subject only after having made many mistakes, especially as a result of not having enough volume and depth of good material in the sub-grade. It is doubtful that, later, in the full knowledge of the case, we can cite a place where too much material was used. Economically wiser construction, during the last 18 yrs. would have involved a different type and a greater amount of material in the sub-grade than in practice, especially in the earlier years.

The side-drain type of construction was used for about 10 yrs., and was abandoned, and what was called a V-drain was adopted. This drain consists of a stone fill of cobbles, in sizes of 8″ and less, in their longest dimensions, and in bad soils was constructed 18″ in depth in the center and 6″ at the sides, under the full width of the macadam, giving, for a 15-ft. road, about ½ cu. yd. of stone fill per lin. ft. Good gravel, instead of cobbles, has been used in the same way, with satisfactory results. This type of drain has been changed, of recent years, so that at present the stone fill or gravel is often placed on a level base. The important end to be attained is to overcome a tendency to irregular frost action, and resultant disintegration of the surface. Our experience in Massachusetts on the greater value of this method of construction over the old system of side-drains is a positive one, and there need be no further basis of argument on this question. Disintegration from frost action has been overcome by this method more effectively than by the side-drain method, and at a very much lower cost. In connection with this matter, it is important that the water be drained from under the road at intervals by means of blind drains.

The following is a copy, in part, of specifications for stone filling:

> At such places as the engineer may direct, stone filling shall be placed. Excavations shall be made to the lines shown on the cross-sections. The stones to be furnished by the contractor may be either wall stones or cobbles ranging in size from the smallest obtainable to those not exceeding 8″ in their longest dimension, and the larger stones shall be placed at the bottom. . . . The stone filling shall be rolled with steam road roller to the satisfaction of the engineer.

In 1913, in the town of North Andover, the Mass. Highway Comm. built a concrete road for a length of about 2 mi. The concrete was put on an old turnpike between Salem and Lawrence. In our preliminary consideration of the type of road to be used for this section, we proposed a macadam road with a 2-in. bituminous upper course of Bermudez asphalt. As the sub-soil was exceedingly bad, it was proposed to put in about 8″ of gravel under the macadam. When the preliminary estimate was made, it was found that the cost of sub-grading was considerable, and made the total estimate for this construction high, and on that account it was decided to adopt a concrete road, as the estimate showed that the concrete road would cost less than the Bermudez road.

The cross-section for the road was such as would be used for a macadam road, with the same crown for subgrade and for surface section. This, however, was changed to a level cross-section for the subgrade before the work was finished. The road was 19′ 6″ in width. The concrete was 8″ deep in the center and 6″ deep at the sides. The mixtures of concrete were 1:2:4 and 1:1½:3. The stone used in the concrete varied in size from ¼″ to 1½″. The concrete was laid in one course, and a number of different brands of cement were used.

After the road was finished, cross-sections were taken at intervals of 50′, and marks were painted where the rod had been held for levels at the center and the sides. In the winter, after a continuous cold spell, these levels were taken again at the same places that the originals were taken, and again in the spring, when the frost was entirely out of the ground. By this means it was possible to know exactly how much the surface had been raised by the action of the frost, and to observe carefully the raising up of the road, and its relation to the cracking of the surface. A diagram of the road was plotted, and notes were made which indicated, in tenths of a foot, the amount of the lifting of the surface. Also, on the same diagram, the cracks on the road were shown. These cracks were, as a rule, longitudinal, and were a little to the right or the left of the center. In nearly every instance, the evidence of this diagram is that where no gravel was placed beneath the concrete or where the concrete was not reinforced, the cracks developed on the road proportionately to the amount of the frost action. This seemed to be invariably the condition, as in no instance did we find these longitudinal cracks well developed except where the frost had affected the road considerably, and it also appeared that in no instance was the frost action severe without the accompanying cracks, except on certain sections of the road where gravel had been placed in the sub-grade under the concrete. We found, also, that the reinforcement of the road with steel rods had a considerable, but not complete effect in offsetting the development of cracks, even where the frost action had been severe.

It may be inferred from our experience on this road that it is an immensely important matter to see to it that the sub-grading is ample, and as permanent for this sort of structure as if we were constructing either a macadam or a gravel road.

In reference to the question of whether or not we may assume that it is possible to reduce the amount of material under a concrete road, and use less than we would if we were constructing a macadam road, I have endeavored to get the opinion of several men who have had considerable experience on concrete construction. The opinion of one was that it was impossible at the present time to determine how much may be saved in sub-grading, but he writes:

> I should be inclined to say, on an average the cost of sub-grading under concrete roads might be reduced from 25% to 50%.

If this is the adopted theory, it would be safe, in making a preliminary estimate for a road of this character, to reduce the amount of the loose stone or gravel under the concrete by one-third.

Austin B. Fletcher, Highway Engr. of Cal., in reply to this question, says:

> With the thin work, mostly not over 4", which is being done so generally on California state highways, there is no saving in cost in the sub-grade, and in my opinion, the cost is considerably increased because of the extraordinary care it is necessary to take in getting a firm, hard sub-grade. I hardly know how this would work out in the case of a thick concrete base but I would hesitate to scrimp on the character of the sub-grade even if 6" or 7" of concrete were used. It is true that the concrete bridges over small inequalities in the sub-grade, but I do not think that one should place too much reliance on this property of the concrete.

In the first part of this paper, it was stated that the old side-drain type of construction was abondoned in Massachusetts over 10 years ago, and a rough stone fill was deposited directly under the macadam, and the results were much more satisfactory than those we had obtained with the side-drain type of construction. It seems evident that this experience with macadam roads should be applied to the construction of concrete roads as well, and the road engineer should not place too much confidence in the side-drains to provide against any disintegration of the surface of the road. It is not meant by this statement to imply that the side drains have no value, but the point is that the stone or gravel filling under the macadam or concrete will be more efficacious and less expensive, and the virtue of it will become apparent after a number of years have elapsed, because it has been found in this state that only after a term of years was it realized that the side drains were becoming failures.

In conclusion, it is plain that it is not wise to neglect the foundations under a concrete road. If the engineer has had experience in determining the proper amount of material to be placed under a macadam road, he may assume that somewhat less will suffice under a concrete surface, but with our present knowledge of this subject he will be careful not to invite a failure by using too little material. It is not always possible to obtain good gravel or cobbles for making a foundation in the immediate neighborhood but it will be best to import them rather than to take a chance with inferior material. The sand or stone should be placed for the full width of the concrete slab.

Concrete Silos are Preferred in Missouri

The Missouri Experiment Station is doing a great deal of work in educating citizens of the "show me" state how to build and use silos. The following data are from its *Bulletin.*

The slogan is "Own a Silo." It is recognized that there is a place for all kinds of silos, and the man who cannot build a permanent silo is urged to build a temporary one. Best of all, he is told how to do it.

Some interesting facts were gathered by the experiment station's investigation that are valuable to the concrete silo contractor.

Reports made by 300 Missouri farmers who have silos shed some light on the subject of silo efficiency, under their farm conditions at least. The following table shows the different kinds of silos in use by these 300 men and also the number of each kind in use:

Kind of Silo	Number	Per Cent
All silos reported	300	100
Stave (wood)	234	78
Solid concrete	33	11
Concrete block	12	4
Gurler	9	3
Home-made, Gurler type, sheeting and tar paper	4	1⅓
Buff Jersey	4	1⅓
Square	2	⅔
Brick	1	⅓
Octagonal	1	⅓
Totals	300	100%

There are several other kinds of silos in use in this State, i. e., the Minneapolis panel silo, vitrified brick, concrete stave, stone, and the steel silo. These are all good silos, but as it happened, none of these was reported in the list of 300. There are perhaps still other good silos are not mentioned. However, as is shown in the foregoing table, 78% of the silos reported were stave silos.

Table 1 will serve to show the difficulties experienced with silos of various kinds and the kind of silo preferred, if another should be built.

From Table 1 it will be seen that the preference is for the concrete silo if another kind is discarded. Out of 100 men having some difficulty with the stave silo, 38 prefer the solid concrete if they should build another silo. Not a man having a concrete silo expressed a desire for another kind in the event that he should build another. It is interesting to note in the right-hand column that the average per cent of spoiled silage in silos of different kinds as reported by the correspondents was greater in the stave silos, the average per cent in these silos being 3%. The average per cent of loss in the solid concrete, the concrete block and the Gurler being 2%, while that in the home-made silos, made of sheeting and tar paper, was 2.8%. However, the per cent of spoiled silage as reported is not great enough in any of the silos to be made a talking point for or against any particular kind of silo. The table is given simply to show results under farm conditions of the men reporting.

The following data may give some idea of the relative cost of silos of different kinds now in use by the men reporting. They show also the advantage in having a silo in which to harvest at least a part of the corn crop, over the old custom of letting the stalks stand in the field or that of putting the corn into the shock. The figures as given by 300 correspondents are shown in Table 2.

The above table in the column headed cost shows that the solid concrete and the concrete block silo cost more money than the others mentioned. However, it must be noted that the sizes of the solid concrete and the concrete block silos as given in the table are considerably greater than those of other silos given.

The figures in the last two columns, which are ours, are intended to show that the cost per ton capacity is more favorable to concrete than is generally supposed.

The cost per ton shows that the monolithic silo is actually cheaper than the wood stave and that the apparently expensive block still costs 1 ct. per ton less than the stave.

These favorable figures are partly offset by the fact that the average concrete silo was somewhat larger and taller than the wood, and it is a well known fact that the greater the capacity of a silo the lower the ton cost.

With due allowance for this fact the above figures are surprising and suggestive.

TABLE 1

Kind of silo in use now	Number reported in use now	Number of silos giving trouble now	Per cent of silos giving trouble	Kind of silos preferred if another should be built: Concrete, number	Stave, number	Gurler, number	Home-made number	Average per cent of spoiled silage
Stave	234	Loose hoop and staves, 77	33.	38	196	..	..	3.
		Blowing down, 15	6.5	..	..	..	..	..
		Frozen silage, 8	3.5	..	..	..	..	..
Solid concrete	33	Cracked, 1	3.	33	..	..	..	2.
		Frozen silage, 1	3.	..	..	..	..	..
Concrete block	12	Cracked, 1	16.66	11	..	..	..	2.
		Frozen silage, 1	8.33	..	..	..	..	..
Gurler	9	Frozen silage, 3	33.33	3	..	6	..	2.8
Home-made sheeting and tar paper (Gurler type)	4	Frozen silage, 1	25.	1	..	..	3	2.
Buff Jersey	4	Frozen silage, 1	25.	1	..	..	..	..
		Spoiled islage, 1	25.	..	..	..	..	..

TABLE 2

Kind of Silo	Size	Cost	Tons	Cost per Ton
Average of all	14.48 ft. x 30.6 ft.	$230.96	102	....
Average of stave	15.1 ft. x 30.9 ft.	291.44	111	$2.63
Average of solid concrete	15.4 ft. x 35.1 ft.	345.25	132	2.48
Average of block concrete	16.3 ft. x 34.1 ft.	390.71	149	2.62
Average of Gurler	13.6 ft. x 28 ft.	126.66	78	1.62
Average of Buff Jersey	12 ft. x 25 ft.	75.00	52	1.44

Information and Consultation: The How-to-Do-It Department

This magazine is for service. Let it serve you, and you help it to serve. You want special information. Ask us. We know the men who know.

Floor Construction for Driveway in Canning Factory

THE QUESTION BELOW IS DISCUSSED BY:

IVAN MUSSELMAN[1]
F. O. WHITE[2]
J. F. FORWARD[3]
W. M. KINNEY[4]

"A corn packing company has a large storehouse about 100′ in length in which it intends replacing the old wooden floor with concrete. The building is on sandy ground and will be filled in about 1′ to bring the floor up to where wanted.

"The company wants the floor through the middle so that loaded teams can be driven over it.

"1. How thick a floor, including top coat, is needed?

"2. Thickness of top coat?

"3. Can floor be made satisfactory without top coat?

"4. How arrange for expansion joints?"

BY MR. MUSSELMAN

In reference to concrete floor for driveway, make thickness 6″ for 2,500-lb. load and 1″ for every 1,000 lbs. more your teams will load.

I would not put on a top coat. The floor will get smooth enough with a little care. Three in. is thick enough where you throw the corn. Put concrete on the sand but be sure you tamp filling very hard. Cut the concrete into blocks like walks or put all in one piece and let it make its own cracks. I wouldn't bother about expansion joints. Our concrete floor is 250′ x 32′.

BY MR. WHITE

Much depends upon the weight and the abuse that will be applied to the floor to know just what thickness the concrete should be.

Question No. 1—4″.

Question No. 2—1″.

Question No. 3—Yes, for floor where looks do not count.

Question No. 4—Several ways, but the least expensive is to cut with a special tool a joint through the concrete every 30′ or so, fill the cut with fine sand, and be sure that the cut is just where the joints come.

Where the teaming is done, I should make the floor 6″ thick, with a top surface 1″, made of the best sand obtainable mixed $1\frac{1}{2}$:1, Portland cement, the top laid on the base as soon as possible, that all may become one.

If I were concreting a floor of the kind that you mention I should not allow for any expansion joints, as I do not think they are required, or would do much good. I should try to lay this floor without any joints showing, to be plain—all one smooth surface.

Another way to lay a good, cheap floor is to use a tooth rammer. This will bring all the fine material to the surface, where it may be troweled off like a top surface job. This mix can be 1:5, plastic, not too soft.

BY MR. FORWARD

It is doubtful that I can give any information of special value to your subscriber in putting down the concrete floor, or driveway, through storehouse. The job nearest like the one the inquirer has to do was putting a driveway through a barn 70′ long. This also was on sandy ground.

Our filling was less than 1′. We used largest stones in our first layer, filling voids with smaller stones and sand, not too wet, but wet enough to pour, making about a 1:8 mix (no cement). Nearer the top we used an aggregate of stone, about $\frac{3}{4}$″ down, and making a mix of about 1:2:4, or 1:2:5. For the final 2″ or 3″, mix of limestone screenings, about $\frac{1}{4}$″ down, and sand, standard, or 1:6 mix. I do not consider that any top dressing is needed. What I regard as more important is the hardening of the surface to prevent wear and dusting. This was done in our case by making a solution of silicate of soda, using 1 part of silicate to 2 parts water. After floor has been laid 2 das. or 3 das., sprinkle with this solution, repeating the treatment say three or four times, 2 das. or 3 das. apart. Be sure not to use the solution in mixing the concrete. When laying floor every 10′ or 12′ we broke joints in the usual way to allow for expansion.

BY MR. KINNEY

All refuse should be removed from the area to be paved and all soft spots dug out and refilled. Sand free from loam should be used for filling, this being spread in layers, sprinkled lightly and rolled with a roller such as is used in paving practice—made of solid concrete from 2′ 6″ to 3′ in diam. and from 3′ to 4′ long, or one equally heavy. The fill should be brought up to a level 6″ below the proposed surface of the concrete pavement.

The surface of the concrete should slope downward toward the center from each side $\frac{1}{4}$″ per ft. of width, so that water will run toward the center, and the whole pavement should slope about 6″ in both directions from the mid-length point toward the end, so that water will flow out of the building. The sub-base should be graded so that the concrete will be of a uniform thickness. A catch-basin connected with a drain should be placed at each end of the driveway.

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[1] Orrtanna Canning Co., Orrtanna, Pa.

[2] F. O. White Const. Co., Cambridge, Mass.

[3] Contr., Hagerstown, Md.

[4] Engr. in chg., Inform. Bur., Universal Portland Cement Co., Chicago

To check the grading of the sub-base, a stiff plank with cleats nailed at the quarter points extending down to the proper level of the sub-base, laid across forms of 2-in. x 6-in. surfaced lumber set up and staked securely to proper line and surface, may be dragged along these forms as a guide, and will show just where the sub-base is high or low. These inequalities can be corrected by spreading or scraping off the earth, which should then be sprinkled and rolled once again. The sub-base is then ready to receive the concrete.

The concrete should be laid in slabs each 25′ long, with 1/4-in. expansion joints between slabs. These joints can be formed by folding several laps of heavy tarred felt paper or by using some one of the commercial paving joint fillers. If felt paper is used in expansion joints, it may be folded over a piece of weather boarding and the material thus assembled staked rigidly in proper position. This joint filler should be wide enough so that when set it will extend about 1/2″ above the surface of the finished concrete. After the concrete has been placed and struck off on both sides of the joint the strip of weather boarding can be pulled out and the pressure of concrete against the paper will compress the folds snugly together.[5] The projecting portion of the joint filler above the pavement surface will eventually be ironed out by vehicle traffic and thus protect the concrete at the joint for several months until it has gained full strength.

Concrete should be a 1:2:3 mixture, which means 1 sack of Portland cement to 2 cu. ft. of hard, clean sand, ranging in size from fine to particles that will pass a 1/4-in. mesh screen, to 3 cu. ft. of hard, durable gravel or broken stone graded uniformly from 1/4″ to 1 1/2″ in greatest dimensions. Materials should be mixed with sufficient water so that slight spading will thoroughly settle the mass to place.

The surface shape and proper 6-in. thickness of concrete are secured by means of a template cut to conform to the cross-section of the surface of the pavement. This template is dragged along the side forms, which act as guiding strips.

After stakes and wooden strips have been removed and the concrete struck off to shape, it should remain undisturbed until it has sufficiently stiffened so that working with a wooden float or trowel does not cause the surface to become sloppy wet. It should not be left so long that it becomes too stiff to work. At the proper time, floating the surface once over with a wooden float used carefully so as to produce an even surface and bring joints level with each other will give the pavement the proper finish.

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[5] Ed. Note—A split float is convenient at this point; see Concrete, July, 1915, p. 41

Use of Coke Breeze as Concrete Aggregate

The Question Below is
Discussed By:
Wm. M. Kinney[1]
Albert M. Wolf[2]

"We have a recent inquiry regarding the use of "coke breeze," a refuse from gas plants, as an aggregate for concrete. It is customary in England for gas manufacturers to sell the large coke as fuel, the material being passed through a screen and the fine stuff, which is described as "breeze," used in concrete for several purposes, principally floors, on account of its lightness.

"Coke breeze contains sulphur, which, if not first removed, is likely to act sooner or later upon the cement in the concrete and however carefully it may be washed before being used, it is almost impossible thoroughly to eradicate all traces of the sulphur. For that reason, we believe that its use was prohibited by the authorities in Germany some years ago, and believe that a similar prohibition has been made in other countries."

By Mr. Kinney

Although there are instances in which coke breeze has been used with apparent satisfaction in concrete work, the use of such aggregate is not recommended by the best authorities at home or abroad.

In a paper presented to the Insurance Inst. of Edinburg, F. A. McDonald, Dist. Eng. to the Hennebique System in Glasgow, says that one often hears of coke breeze being recommended as an aggregate for concrete used in the construction of fireproof floors, and that this material is favored by the contractor principally on account of its cheapness, comparative lightness and so-called fireproof qualities. Mr. McDonald regards regards coke breeze as "fuel to the fire" and so far as fireproof qualities are concerned compares it to coal.

Concrete and Constructional Engineering reports a paper upon "The Dangers of Breeze Concrete" presented to the Soc. of Architects by D. B. Butler. This paper was followed by an interesting discussion, the conclusions of which are stated by the chairman and concurred in by Mr. Butler being that the whole crux of the matter lay in the architect seeing that he really got coke breeze when he specified it, for at present much of the so-called coke breeze is rubbish gotten from anywhere. Tests carried out by the British Fire Prevention Committee seemed to indicate that coke breeze floors were fire-resisting, and that although they might become incandescent when exposed the fire would not burn through.

In a report prepared by a special committee of the Structural Assn. of San Francisco it was stated that sulphur, as such, will probably not attack iron or steel reinforcement in concrete, but when oxidized and in the form of H_2SO_4 there is little doubt as to its destructive properties, and corrosion may be set up by concrete containing coke breeze aggregate. Although no weakening of the embedded steel may be developed for years, the latent danger of such aggregate is a serious matter.

The Sunshine Coal & Coke Co., Uniontown, Pa., constructed several hundred ovens in 1910, using coke breeze as an aggregate. This work is reported as satisfactory, although the company claims that concrete made with coke breeze should not be placed too near the heat, as the coke has a tendency to burn out and disintegrate the concrete. Another point which should be borne in mind is that reinforced concrete made of coke breeze aggregate is not satisfactory where the concrete is subjected to a great deal of moisture, as the concrete will be porous, absorb water and thus result in corrosion of the iron or steel.

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[1] Engr. in Chg., Inspection Bur., Universal Portland Cement Co., Chicago

[2] Prin. asst. engr., Condron Co., Chicago

The Pocahontas Consolidated Colleries Co., Pocanhontas, Va., is said to have used coke breeze quite extensively in making concrete block, the coke breeze varying in size from that of a grain of sand up to 1½" in diameter. A 1:5 mixture was used and the blocks laid in walls of several 2½-story buildings, bearing the weight of roof and floors. No failure has been reported, but this single example should not encourage the use of coke breeze as concrete aggregate.

By Mr. Wolf

In regard to the use of "coke breeze" as an aggregate for concrete, I wish to say that although used in England to some extent in jack-arch floor construction, its use in this country is not at all warranted because of the plentiful supply of aggregate or a more stable character, such as stone, sand and gravel.

If an aggregate is desired which is lighter than stone, clean, screened steam boiler cinders can be used and although the writer does not favor the use of cinders for concrete they would prove infinitely more satisfactory and less likely to injure the reinforcement by corrosion than coke breeze, which contains a much greater quantity of sulphur. What the engineers of this country are striving for is concrete of a permanent character and this can never be obtained by the use of cinders or coke breeze aggregate, and for this reason they should not be considered as concrete materials.

Coloring a Concrete Wall With Grout

The Question Below is
Discussed By:

Adolph Schilling[1]
Oswald C. Hering[2]
W. M. Kinney[3]

"I should like to know whether or not I could color a concrete wall successfully with the use of cement grout to which had been added the necessary coloring matter. What is the experience in work along this line?"

By Mr. Schilling

If it is desired only to give a stated color to an existing concrete surface, be it wall or floor, I would recommend the use of a standard cement color; this color should be applied in stipple fashion, unless brush marks are not objectionable in the finished surface. There is no question about the cement color adhering to the concrete, which could not be seen, if colored cement grout were applied. If the concrete surface is pitted or rough, and the grout is to be a filler and surface as well as a color medium, then the usual precautions must be used for making the grout adhere to the concrete.

Wherever possible I would strongly recommend the use of standard cement color; the concrete should be dry when it is applied; if the wall surface is very porous, two coats may be necessary, which serve as waterproofing. Cement mixed with a pigment always diminishes the color value of the pigment, and the latter never adds to the natural qualities of the cement, while it is often detrimental. I would not use cement grout to which color had been added, to color a concrete surface.

By Mr. Hering

There are but two ways that I know of to produce color effects in concrete that are of lasting and artistic value. The first and best is through the medium of colored aggregate. The second is to cover the surface with a paint-like substance which has as little as possible the appearance of paint. Any coloring matter mixed in as an ingredient weakens the concrete. There is a manufactured medium which appears to have a high degree of adhesive, non-fading and waterproofing qualities—and when applied to concrete or stucco as described in an account of work at Ogontz Hill, near Philadelphia[4] produces very pleasing effects superior to most paints.

By Mr. Kinney

Experience in work along this line is that a mixture of cement and water is frequently applied to paint concrete walls but color has seldom been used. If too heavy a coat is used the job will be unsightly; otherwise, good results may ordinarily be obtained, but the color effect is not permanent. The concrete walls to be painted should be thoroughly wetted down before the mixture is applied, and to maintain a good appearance the application will probably have to be repeated annually.

One of our correspondents has related his experience along similar lines by saying that a paint mixed with 2 parts of cement (by weight) with 1 gal. of buttermilk, tinted by adding Venetian red to give the desired color, will accomplish the same purpose. Ordinarily this mixture does not cost more than 2 cts. or 3 cts. per gal. and can be applied like oil paint. One coat has usually been found sufficient. Mineral white can also be used as a coloring pigment to produce a white surface if desired. On interior work, such as the walls of cow barns, carbolic acid may be added to the paint as a disinfectant, if desired.

There are now on the market several brands of cement paint which may be applied directly to concrete walls and by the use of which several different colors may be produced. These should be applied to dry walls only.

Ordinary lead-and-oil paint in any color may be applied to a concrete wall by using sulphate of zinc in accordance with directions given in our discussion entitled "Application of Sulphate of Zinc to Concrete, Preparatory to Painting."[5]

Cause and Prevention of Efflorescence

The Question Below is
Discussed By:

E. L. Conwell[1]
Wm. M. Kinney[2]
Clifford Richardson[3]

"Can you give information as to the cause of efflorescence and methods that may be used to prevent trouble from this source?"

By Mr. Conwell

The subject of efflorescence, while extremely broad, can easily be exemplified by a classification of the various kinds of efflorescence. We have investigated this subject at frequent intervals for the past 10 yrs. and find that the various kinds of efflorescence can be classified as follows:

No. 1—Efflorescence appearing on

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[1] Haddon Heights, N. J.

[2] Archt., N. Y. C.

[4] Concrete-Cement Age, Jan., 1915, p. 9

[1] V. P., Henry S. Spackman Engrg. Co., Philadelphia

[2] Engr., Universal Portland Cement Co., Chicago

[3] Cons. engr., N. Y. C.

[5] Concrete-Cement Age, Jan., 1915, p. 37

brick work. This appears to be invariably due to soluble salts contained in the brick themselves. In all cases in which we have investigated this sort of efflorescence we have found it to consist of sulphates or carbonates of sodium or potassium.

No. 2—Efflorescence appearing on white coat on plastered walls. This efflorescence is due to the calcined plaster (plaster of Paris) added to the white coat to give it strength and hardness and it is simply crystals of hydrous calcium sulphate.

No. 3—Efflorescence appearing on concrete products. In most cases this comes from the cement used and consists of calcium sulphate, calcium carbonate and, in some cases, traces of sodium and potassium carbonates.

By Mr. Kinney

Probably the best way in which we can serve you is to give a number of references from our library files to articles in technical journals that deal with this subject.

Cement World, for July, 1913, contains on p. 80 a report presented to the Internatl. Assn. for Test. Mat. regarding the causes of efflorescence.

Building Age, July, 1911, p. 39, Aug., 1911, p. 43, contains several interesting discussions under the subject head, "What Causes Efflorescence?"

Other references to articles or discussions on the same subject will be found in Concrete-Cement Age, July, 1913, p. 29, Aug., 1914, p. 77; *Engineering News,* Aug. 25, 1904, p. 169, Dec. 22, 1912, p. 16; Stevens Institute *Indicator,* Jan., 1905, p. 54; Bur. of Standards, *Technologic Paper* No. 12, p. 106.

By Mr. Richardson

It is a well known fact that on mixing Portland cement with water free lime is liberated from the decomposition of the aluminates and silicates present. Where sand mortars or concretes are not dense the free lime is brought to the surface and left there on evaporation. This can be prevented by making a denser concrete or by the application of waterproofing materials which will close up the surface. I am not aware that any particular studies have been made of this question and should say that its prevention could be brought about by provision for dense mortars. The problem should be treated in this way rather in applications of preventatives.

Aggregate Sizes to Be Kept in Stock

The Question Below is Discussed By:

F. W. Renwick[1]
John S. Porter[2]
W. A. Esson[3]
J. Arthur Garrod[4]
R. P. Duffy[5]
A. M. Wolf[6]
E. C. Potter[7]
B. P. Webber[8]
E. S. Warner[9]
L. R. Witty[10]

"What sizes of concrete aggregate should a dealer be prepared to supply? In a general way, what sizes are in greatest demand and how large stocks should be carried?"

By Mr. Renwick

In reference to sizes and character of aggregates universally used for various sorts of concrete construction, I would say that heretofore these various sizes were generally the results of the individual opinions of different engineers, and coming as they did from different schools of engineering, and being influenced undoubtedly by local conditions in which the material was produced, it left the producer in a very impractical position when it came to the installation of a plant to determine the most desirable sizes of screens necessary to produce the most common sizes of material.

At the last meeting of the Nat. Sand and Gravel Producers' Assn. this subject was discussed extensively, and a tentative agreement made by all members present to standardize their plants for making certain sizes of material, which were, for large concrete, gravel which would pass through a 2-in. ring and be retained on a $1\frac{1}{4}$-in. ring, commonly known as No. 9; another size which would pass the $1\frac{1}{4}$-in. ring and be retained on a $\frac{3}{8}$-in. ring commonly known as No. 8; material passing through $\frac{3}{8}$-in. ring and retained on a $\frac{1}{4}$-in. ring to be "roofing gravel" or "top dressing"; while any material passing a $\frac{1}{4}$-in. ring would be known as "torpedo sand." These sizes appear to meet the requirements of $\frac{9}{10}$ of the engineers in this locality—where more gravel is produced in the same area than anywhere else in the U. S.—and also with the engineers in the majority of adjoining states, the larger material being used in concrete of 6-in. thickness or greater, and the No. 8 for anything under 6″, either reinforced work or plain. A very popular size in this section of the country is a mixture of approximately equal parts of the No. 8 and the No. 9, which being mixed 2 parts of gravel to 1 of torpedo sand, makes an ideal concrete mixture. There is an effort now being made to have the sizes above mentioned adopted as a standard by the Am. Soc. for Test. Mat., and this would eliminate considrable expense and experimenting in catering to the opinions of some engineers who insist upon specifying unusual sizes on certain jobs.

So far as keeping of sizes in stock is concerned, this would necessarily be covered largely by the character of the gravel produced in the particular locality in which a stock pile was being made. For instance, there are certain gravel pits which run so light in large material that it would be practically impossible to accumulate any 2-in. material in excess of the daily output of the plant. The same occasionally will apply to the smaller sizes, as well as to the torpedo sand, the practical idea being, as we understand it, to stock the surplus of the daily capacity of the plant over the selling requirements, with a view to selling from this stock pile in the winter months when the plant is not in operation.

By Mr. Porter

We think that sizes running from a coarse, sharp sand to pebbles and fragments up to 2″ or 3″ in diam. should be stocked, say, six sizes in all; then they should be so kept in stock that they could be furnished separately or combined in any desired proportion.

The varying character of the construction would govern not only the size or sizes to be used but also the proportions of their combination.

Where the work requires exceptional resistance to a crushing load the aggregate should be so proportioned that it will be as free as possible from any voids, while for work that did not need much strength the combination would not be of such importance.

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[1] Vice-pres. and gen. mgr., Chicago Gravel Co., Chicago

[2] Sales agt., The Huron Shore Gravel Co., Saginaw, Mich.

[3] Pres., The Esson Sand & Gravel Co., Chicago

[4] Genl. supt., Aberthaw Const. Co., Boston

[5] Sec., Richardson Sand Co., Chicago

[6] Condron Co., Chicago

[7] Sec., Biesanz Stone Co., Winona, Minn.

[8] Sec. and treas., The Weber Chimney Co., Chicago

[9] The Akron Gravel & Sand Co., Akron, Ohio

[10] Genl. mgr., Wabash Sand & Gravel Co., Terre Haute, Ind.

Of course satisfactory concrete work can not be done unless the materials are separated and recombined in proper proportions, for there are few or no natural deposits that are of sufficient uniformity to make their use available to secure constant excellence, and occasional failure is almost as bad as frequent failure, on the principle that a chain is only as strong as its weakest link.

We store our materials in bins that deliver to a moving belt which delivers the load to cars or wagons. By regulating the flow of the different sizes we can furnish an aggregate that is satisfactory in nine cases out of 10 and find that it meets almost every demand that we have.

The proper quantities of the different sizes would vary with the sort of work most prevalent in any locality, although it is usually safe to figure that the smallest three or four sizes would be most in demand, as they are not only used in light work but also as part of the aggregate in work of a heavy and substantial nature. Where reinforcement is used in considerable quantity the size of the separate pieces of the concrete must naturally be small enough to "pour" readily without clogging in the reinforcing material, and as a good deal of this work is being done it tends to keep the proportion of large-sized units down to a minimum.

By Mr. Esson

The class of material most in demand is what is known here in Chicago as No. 8 gravel, of a size running from ⅜″ to 1½″. This is used for sidewalks, reinforced concrete, curb and gutter work; in fact, nearly all kinds of concrete come in under this bulk. For street work and heavier foundations No. 9 gravel is generally used, being from 1″ to 2″ in size. The demand for sand is principally for what is known in this district as torpedo sand, being from ¼″ down. This is used for all classes of concrete.

As to what a producer should mostly keep in storage, we always have a large supply of the above mentioned No. 8 gravel and torpedo sand. The No. 9 gravel being principally used for street paving, the demand is variable, but when used it is used in large quantities and it is well to have a supply of this also on hand in anticipation of large orders. Roofing gravel, which is from ⅜″ to ¼″, is not in demand in large quantities but if a producer wishes to keep this on hand for customers it is well to have a storage pile so that he can remove the screen through which this passes, as it is not likely that there will be a steady market for this size. Plaster sand, which is finer than torpedo sand, is in demand about similar to the roofing gravel.

The production of material depends a great deal, of course, on local conditions. We should say, however, that in every district it is always necessary to produce concrete stone, No. 8 and torpedo sand.

By Mr. Garrod

So far as our business in New England is concerned we find that the aggregates most in demand are crushed stone of various natures and sizes and clean, coarse, sharp sand. In New England we have many ledges of both granite and trap rock. We find that the crusher people who run these ledges as commercial propositions are not, as a rule, prosperous. Their plants have often grown from a small beginning and are inadequate. The sizes they produce are usually governed by a large market for road sizes. We find that we can usually purchase stone that will pass a 2¼″ ring, usually called by them 2-in. size; also stone that will pass a 1-in. ring, called by them ¾-in. size; and pea stone, often mixed with a great deal of dust. This passes a ½-in. ring, and has some of the fines removed by an outside dust jacket of about ⅛″ x ⅛″ mesh wire. This seems to be the general method employed in dividing. In some large plants in Connecticut and in the western part of this state more sizes are made, and in connection with a large order it is nearly always possible to get the producer to put in screens and reserve bins for the use of the particular job.

There are several people in this neighborhood making a business of supplying gravel by railroad cars. This business is fostered by the Boston & Maine R. R., but discouraged by the New York, New Haven and Hartford R. R. The plants are, as a rule, of a temporary and makeshift nature, producers generally being left with an excess of perfectly usable sand, and being prohibited by the railroad from crushing their larger boulders and shipping at gravel rates, they are apt to work in as many big boulders as they can, so that the gravel supply is not on a satisfactory commercial basis. The supply is intermittent, and subject to all sorts of delays.

At least one large water-side plant is equipped with modern machinery, and has been making water deliveries of a satisfactory gravel aggregate including crushed boulders in regular concrete sizes, such as are supplied by the crushed stone men.

Local supplies of sand are fortunately obtainable almost anywhere in this territory, the sand generally being satisfactory for concrete work when carefully selected. Our company makes a practice of always having sand sampled and tested in a properly equipped laboratory when a new source of supply is tapped.

For dams and hydraulic developments, which are so often situated in remote places, this company has usually quarried and crushed its own stone, and has occasionally had to install a washing apparatus when the local supply of sand has been unsatisfactory.

The sizes kept in stock have been described in answering the first question. We find, however, that in larger cities, notably in Philadelphia, excellent supplies of dredged gravel and crushed pebbles are obtainable and are loaded onto cars or teams by well equipped producers in this line of business.

In Buffalo and vicinity the aggregate universally employed is dredged from the Niagara River. This is separated into the sizes of "river run," ¾-in., and sand. Sizing is obtained by applying different sizes of bar screens for filling different compartments in vessels when the dredge pump is operating. Buffalo is exceptionally well supplied with concrete aggregate. The so-called ¾-in. size, which includes, as a rule, everything dredged which will pass a bar grate with a distance of ¾″ between the bars, when they are new, usually contains a slight excess of sand, but forms a very satisfactory concrete aggregate.

By Mr. Duffy

The sizes of our materials which are produced to meet the specifications of this market, are as follows:

Washed torpedo sand, known as No. 2, from ¼″ down, used for all concrete work.

Washed roofing gravel, known as No. 5, from ⅜″ down to ¼″, used for roofs.

Washed crushed gravel, known as No. 8, from 1¼″ down to ⅜″, used for sidewalks, etc.

Washed crushed gravel, known as No. 9, from 2″ down to 1¼″, used for paving.

In regard to the materials kept in stock, the following is about the proportions dealers in this vicinity handle:

Two yds. of No. 8 gravel to every

yd. of No. 2 torpedo sand, as these are about the proportions used on work.

Enough No. 5 to take care of demands, usually four or five carloads. The No. 9 gravel is usually handled from car direct to job.

In regard to the amounts to be kept in the yard, this is entirely governed by several conditions, such as —what distance shipments have to come, and how long it takes railroad to make the delivery; what the average daily demands are. In this market the dealers have to pile enough material in their yards late in the summer so that they can take care of the winter business, as all washing plants cease to operate when weather becomes so severe in the fall of the year as to freeze the water which is used to wash materials. Plants start operating about Mar. 15, weather permitting. We do not pile any great amount of materials at washing plants for shipments to be made in the winter months, as some materials would freeze in transit and would be very expensive to pick out of the cars.

By Mr. Wolf

In Chicago the fine aggregate used for practically all classes of concrete work is torpedo sand, a well graded bank sand with a goodly amount of small glacial pebbles.

In mass work crusher-run limestone, varying from 2″ to dust, is occasionally used. In general, however, 1½-in. crushed limestone or washed gravel is used for mass work, and heavy reinforced concrete building work. For thin slabs and for columns ¾-in. crushed limestone or gravel is used almost exclusively. Contractors in general prefer to use gravel for the coarse aggregate, especially where concrete is to be spouted or spaded, since the resulting mixture is more easily handled.

By Mr. Potter

Washed and screened gravel from 1¼″ to ¼″ would be the size most generally used for concrete roads, pavements, dams, etc., and the sizes which, from our experience, should be kept in stock are washed, screened gravel, 1¼″ to ¼″ and washed and screened torpedo sand, ¼″ and under.

By Mr. Webber

I would say that the aggregate most used, so far as I have encountered it in various kinds of work, consists of concrete sand which should be sharp, well graduated and run fairly coarse and gravel or stone passing through a 2-in. ring and gravel or stone passing through a 1-in. ring.

As to what sizes should be kept in stock, it is rather difficult to determine as in heavy foundation work the larger sizes of stone or gravel are generally used and it would be difficult, unless a dealer has a large space to store such materials in, to have enough on hand for this work and also, it is usually more convenient and economical for the contractor to have such materials delivered direct from the car to the site of the work. For smaller work, such as walls and general reinforced work, the 1-in. material is used generally, but on that work also there are usually facilities to deliver material direct from a car and it is pretty hard to say which sizes should be carried in stock unless the character of work that is going on in the immediate vicinity is known.

By Mr. Warner

As to the size and character of aggregates most used, I wish to state that washed matrial is specified in nearly every instance.

It is a fact that conditions change with locality, customers being educated to conditions in their own particular locality, although these same customers will adhere to your conditions when shown the particular advantages.

Akron, Cleveland and Youngstown being our best and biggest markets, and towns where reinforced concrete is used extensively on account of its fireproof features, 1-in. gravel of course is in greater demand than either ½-in. or 2-in.

Sand through a ¼-in. round screen and gravel that will pass a 1-in. round ring is in greatest demand, but we have installed screens with ½-in. and 2-in. perforation.

Sand and gravel is too low a classed product to afford to stock unless there is an over-production of one of the sizes, or it should be possible for you to secure a premium for it in a season when the demand is greater than the production.

We have established several outlets which we use as dumping markets, where under ordinary conditions we would not ship, but when we have a surplus, we dump it at a price that will move the material rather than to store and reload when the market demands. These conditions change with the capacity of the plant and the requirements in the locality. We have a plant that will produce from 100 cars to 125 cars per da. of 10 hrs. and within a few hours' notice can take care of any demand that is likely to arise.

By Mr. Witty

Concrete aggregate as used in this locality is about as follows:

For Building Construction—Gravel, the largest size passing a 1½-in. screen, mixed with sand, well graded, with from 55% to 65% of the larger material retained on a ⅛-in. screen.

For Concrete Roads or Streets—Gravel, anything passing a 1½-in. screen and retained on a ¼-in. screen. Sand, anything that will pass a ¼-in. screen.

For Sidewalks and Curbing—We sell quite an amount of 1½-in. down, mixed with sand, ⅝-in. down, mixed with sand and ⅜-in. down, mixed with sand.

We also make a 2-in. and a 3-in. size that we frequently furnish for heavy work.

We find for concrete graded 1½-in. down to sand:

1½-in. to ¼-in. gravel,
⅝-in. to ¼-in. gravel—for roofing,
⅛-in. and ¼-in. sand, the most desirable for stock.

We have not made any preparations for storage, but the time is close at hand when we will have to do so, as the demand for material is very quiet until Sept. and Oct., when the farm work is over and demands are plentiful and when road building is at its height. We find it will be necessary to pile quite an amount of 1½-in. to ¼-in. and ¼-in. down and reclaim it in some manner when the demand will justify it.

Skewed Joints Recommended for Concrete Road Construction

Skewed joints for concrete roads, instead of joints at right angles to the direction of traffic, are recommended by C. H. Moorefield and James T. Voshell, of the U. S. Office of Pub. Roads, in *Bulletin* 249 of the Dept. of Agriculture. With the joint at right angles the two wheels of a vehicle strike the joint at the same time and thus produce the maximum amount of impact. By skewing the joint at an angle of about 15° the wheels strike one at a time, and the total resultant impact is reduced by at least one-half. This is advantageous to the traffic and the pavement both, and since the difficulties involved in constructing skewed joints are not at all serious, there is no apparent objection to their use, according to expressions in the *Bulletin*. Wider angles of skew have not proved satisfactory, as the sharp corners frequently cracked.

Correspondence: A Department in Which the *Reader* Becomes the *Writer* □

This is your department. It is informal. Use it. This is the place for letters which have either inspiration or information for the "other fellow." It is well to remember that you are usually in his position. If you are to get the good out of these columns, why not help to make them good? Write about your work. Help the Other "other fellow." □ □ □

Steel Reinforcement Promises Much in Development

—A LETTER FROM ALLEN BRETT[1]

Field methods in handling concrete work have greatly developed in the last 10 yrs. Forming methods are becoming greatly standardized. Modern highly developed equipment has made possible the mixing and placing of the concrete in the most efficient way. Every effort, too, has been made in the fabrication and placing of the reinforcing steel to develop workmanlike and accurate methods.

On the whole, however, it does not seem that the development in handling the concrete reinforcement has kpt pace with the other developmnt. One point especially that has not received the attention it should is the *definitely known, exact position of the steel within the finished structure.* No matter how carefully the building may be designed, no matter how carefully the formwork is built and braced, and the grading and mixing of the concrete watched, in order to insure a good structure the steel must be placed accurately and held accurately in place. For instance, in a beam in flexure the efficiency of the steel intension is directly relative to the effective beam depth. If this effective depth, say for instance, is 8″ and the steel is out of place—is raised up—1″ or so in the beam, the steel is only 7/8 effective. If, on the other hand, the steel is down too low below the surface, it is in danger from fire and is also ineffective.

The steel must be right and must be in its right position and must be there to stay. The past decade or more has witnessed many efforts to improve steel methods in handling reinforcing steel. The effort has been to produce a rigid, self-contained, easily handled reinforcing unit, to overcome and eliminate the weak points and inefficient points of hand fabrication.

In going at this problem there are certain essential field requirements which must be met. Each individual reinforcing unit should be fabricated into a positive and rigid member so that it cannot be harmed in transit or in handling. The fabrication should be workmanlike and accurate and the steel must not be in units too large to handle conveniently.

It is up to the man designing reinforced concrete to take these field requirements and square them with the basic, technical essentials which have been developed and formulated by field, office and laboratory practice.

The first workers in this field sought diligently after the elusive, efficient mechanical bond. Present-day thought seems to indicate that it is more important to develop mechanical bond by the fabrication of a unit than by the surface structure of the bar itself. Most of the efforts in developing reinforcing units have been centered around the web or shear reinforcement in a beam or girder unit. Over five years ago, before the Nat. Assn. of Cement Users, now the Am. Concrete Inst., John Stephen Sewell pointed out, in fact, he stated definitely, that inclined stirrups are superior to vertical stirrups and that stirrups rigidly attached to the main bars are superior to loose stirrups. An unbiased study of conditions will show conclusively that the true truss action of the rigidly attached inclined shear member develops the greatest strength for the steel used.

Then, too, these diagonal tension or web members have an adaptable position. It should be possible to use as many as required, of the length required, and their position should not be controlled in any way by conditions governing the production of the bar itself.

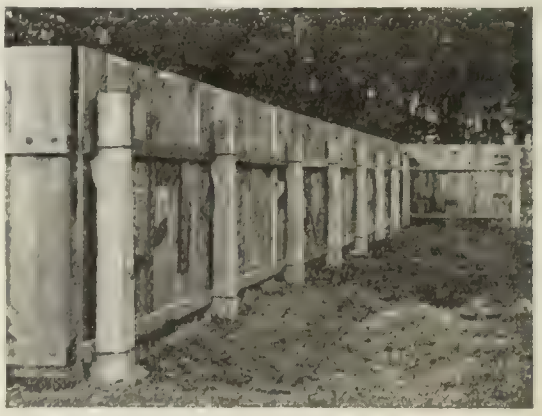
American engineers have not paid enough attention to negative tension and the upper anchorage of the web members. This is a point that should be carefully watched.

The foregoing are the technical and field requirements which the engineer must face in designing and supervising the construction of a concrete building. A no less interesting phase of this matter is the method of marketing concrete reinforcement. Our nearest analogy—and it is none too near—is that of structural steel. We find that today structural steel as an engineering material is handled along certain definite, well understood lines. Competition in structural steel is made possible by the factor of shop fabrication. Steel shapes are bought at a well known standard price. Fabricating firms bid against each other, due to their ability to fabricate at varying cost. Some have better equipment, some have better workmen, some have better location. Isn't it possible that the development of reinforcing steel will to some extent parallel our present-day structural steel practice and that we shall see structural steel shops submitting competitive figures on accurately fabricated reinforcement?

We must develop methods in handling reinforcing steel which will eliminate as much as possible the personal field equation, making the field operation short, swift and sure. It is an interesting subject. The next 10 years will probably see a great many changes.

A Fence Post for a Barn Yard Fence

The accompanying illustration[2] will suggest to many fence post manufacturers a new line of work which may interest farm buyers. "The picture tells the story." Extra heavy posts with projecting shoulders support the plain board fence. The stringers are held by a U-shaped staple entirely encircling the post and holding the stringers by means of nuts.



BARNYARD FENCE

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[1] Cleveland

[2] Courtesy D. & A. Post Mold Co., Three Rivers, Mich.

Organizations

American Concrete Institute, Charles L. Fish, Secretary, Harrison Building, Philadelphia, Pa.

American Concrete Pipe Association, Secretary, E. S. Hanson, 538 S. Clark St., Chicago.

American Highway Association, I. S. Pennybacker, Jr., Executive Secretary; Colorado Bldg., Washington, D. C.

American Road Builders' Association, Secretary, E. L. Powers, 150 Nassau St., N. Y. C.

Association of American Portland Cement Manufacturers, Percy H. Wilson, Secretary, Bellevue Court Building, Philadelphia, Pa.

Cement Products Exhibition Co., 208 S. LaSalle St., Chicago, Ill.; Robt. F. Hall, Secy., Chicago Cement Show, Coliseum and First Infantry Armory, Feb. 12-19, 1916.

Iowa Association of Cement Users, Secretary, H. H. Dean, Glenwood, Ia.

Mid West Cement Users' Association, Secy.-Treas., Frank Whipperman, Omaha, Neb.

Pan-American Road Congress, Oakland, Cal., Sept. 13-17, 1915; Gov. George W. Gates, Vermont, Chmn. Ex. Com.

Second National Conference on Concrete Road Building, J. P. Beck, Sec'y, 208 So. LaSalle St., Chicago. Chicago, Feb. 15-18, 1916.

International Engineering Congress 1915

The Internat. Engrg. Congress will convene in the Auditorium Bldg., Civic Center, Hayes and Larkin Sts., San Francisco, Cal., Sept. 20-25.

Brig.-Gen. G. W. Goethals, builder of the Panama Canal, will preside. The papers to be presented are grouped by subjects as follows:

Opening Session, Sept. 20, at 10 a. m. The Panama Canal, Sept. 20, at 2 p. m. Waterways (4 sessions), Sept. 21, 22 and 23. Irrigation (4 sessions), Sept. 23, 24 and 25. Municipal Engrg. (5 sessions), Sept. 21, 22, 23 and 24. Railway Engrg. (5 sessions), Sept. 21, 23 and 24. Materials of Construction (5 sessions), Sept. 21, 22 and 23. Mechanical Engrg. (6 sessions), Sept. 21, 22, 23 and 24. Electrical Engrg. (3 sessions), Sept. 23 and 25. Mining Engrg. (3 sessions), Sept. 21, 22 and 23. Metallurgy (5 sessions), Sept. 21, 23 and 24). Naval Architecture and Marine Engrg. (7 sessions), Sept. 21 to 24. Aviation (1 session), Sept. 23, 10 a. m. Refrigeration (1 session), Sept. 23, 2 p. m. Architectural Engrg. and Engrg. Education, Sept. 24, 10 a. m. Heating Ventilation and Building Management, Sept. 24, 2 p. m.

Papers of interest to the concrete field are to be presented Tuesday, Sept. 21, afternoon session. Materials of Construction Section as follows:

"Aggregates for Concrete," Sanford E. Thompson, Mem. Am. Soc. C. E., Mem. Am. Soc. M. E., Newton Highlands, Mass.; "Probable and Presumptive Life of Concrete Structure Made from Modern Cements," Bertram Blount, London, England; "Volume Changes in Concrete," Alfred H. White, Professor of Chemical Engrg. at the University of Michigan, Ann Arbor, Mich.; "Waterproof Concrete," Richard L. Humphrey, Mem. Am. Soc. C. E., Consulting Engr., Philadelphia.

Wednesday morning, Sept. 22, Harrison S. Taft, Cons. Engr. of Seattle, Wn., will present a paper, "Use of Wood and Concrete in Structures Stnding in Sea Water, with Special Reference to Dock Work."

Saturday, Sept. 25, morning session, Electrical Engrg. Lecture. Albert F. Ganz, M. E., Prof. of Electrical Engrg., Stevens Institute, Hoboken, N. J., will discuss "Effects of Electrolysis on Engineering Structures." Presumably this paper will contain a valuable contribution on the effects of stray currents upon reinforced concrete.

Mutual Housing Conference Meets at Minneapolis

The Fourth National Conference on Housing in America will meet at Hotel Radisson, Minneapolis, Oct. 6, 7 and 8, 1915.

The preliminary program indicates that the time will be well filled and includes among the speakers nationally known authorities on housing and civic problems. Arrangements have been made for inspection trips, allowing those attending the conference to see what is being accomplished toward better housing in Minneapolis.

Concrete Piles for the Boston Braves' Ball Park

In the article in the Aug., 1915, number of Concrete describing the new National League Ball Park at Boston, the fact that the foundation of the grand-stand involved the use of 350 pedestal concrete piles[1] was unintentionally omitted.

Mr. Cotten's Article on Retaining Wall Design

By the omission of hand-set parentheses, two equations in S. M. Cotten's article on pp. 63-67, issue of Aug., 1915, were made to appear somewhat obscure. At the bottom of the middle column, p. 65, the equation should stand:

$$W_1 a + W_2 \left(\frac{2}{3} l \frac{l-x}{2} \right) = \frac{Ph}{3}$$

and that at the top of the next column:

$$W_1 a w_2 h (l-x) \left(\frac{2}{3} l - \frac{l-x}{2} \right) = \frac{ph^3}{6}$$

Few things are more irritating to an author than to have his ms. butchered. Few things are more ghastly to a publisher than to see carefully guarded against typographical errors staring him in the face from the completed work. We publish the above corrections with regret that they should be necessary and with pleasure in setting Mr. Cotten right with our readers.

Steel Forms Compared with Wood

The appearance of a steel form job is much better than that obtained with wood. The lines are true, The surfaces are smooth, with none of the irregular corners resulting from wood forms when the boards shrink, or where, if a little weak, they spring. It is much easier to finish the surface after the steel forms are stripped.

But the small wedges and keys which are used are a nuisance. They are so small that they are easily lost. On one job we provided three times as many as were needed to set up all the forms. After the forms had been used four times there were hardly enough keys and wedges left for the fifth. We tried to save them by putting a man with a pail at the special task of picking them up as soon as they were removed, but had to buy more. The bonding together and wedging of panels is something which will have to be studied out carefully by the makers, so that the keys will stay with the plates and not be lost by falling to the ground.—Leonard C. Wason, Pres., Aberthaw Const. Co., Boston.

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[1] MacArthur Concrete Pile and Foundation Co., N. Y. C.

Building Concrete Silos — The Plastered Silo

In the July, 1915, and the Aug., 1915, number of CONCRETE *methods of constructing concrete silos, both unit and monolithic, are discussed.*

Another permanent type of silo which is especially valuable where the coarser concrete aggregates are unavailable is built by plastering with Portland cement mortar on a metal base.

The Kansas Experiment Station has specialized on the development of this type and has published the results in great detail. This article was prepared from information furnished by that Station and is the third and last of the present series of articles on concrete silos.

The foundation must be prepared by excavating to a suitable depth and pouring a substantial wall to slightly above ground level. When the concrete is within about 5″ of the top of the foundation the first course of metal lath should be set in place. This is done by using a sweep from the center stake from which the foundation has been struck. The metal should be carefully bent to exact curve and positioned 2″ outside the inside finish line of the silo. The concrete of the foundation is carefully worked around the metal and allowed to set before starting the superstructure.

THE INSIDE SCAFFOLD

A working scaffold is required before raising the temporary wood frame is begun and this is constructed as shown at Fig. 1, using four or six poles according to the size of the silo, six legs being used in silos over 14′ diam. The platforms should be 6′ 6″ apart and a leg should not come opposite the door opening. The scaffold should be perfectly plumb and thoroughly braced, and if very high, guyed with wire.

MAKING THE PLATE

The plate is made of segments of 2-in. plank cut to the proper radius and spiked in place as the studs are raised. Table 1 gives the number and size of segments for various sizes of silos.

DOOR FRAME

The door recommended is continuous, the jambs being formed in the concrete as cast. This is undoubtedly the least expensive and most permanent jamb that can be made. The door frame form is shown in place in Figs. 5 and 6 and the construction in detail in Fig. 10. The form is simply a box provided with a strip in the corner, which forms the rabbet for the doors.

TABLE I—NUMBER AND DIMENSIONS OF PLATE SEGMENTS

Inside diam. of Silo	Dimensions	No. required	Radius
12′	2′ 10½″	26	6′
14′	3′ 4⅕″	26	7′
16′	3′ 10″	26	8′
18′	3′ 9″	30	9′

Both sides are in two pieces cleated, one to admit the metal lath, the other to secure the tie-rods. The form is built on the ground, carefully straightened and braced, then raised to position. The work should be planned so as to raise the form in the morning so that by night the frame may be up and secure.

STUDDING

The studding is prepared on the ground by spiking together two or three lengths of 2-in. x 4-in. studding. Care must be taken to place them together so that any crooks will tend to offset each other and the whole stud be approximately straight. The plate sections are now hoisted to the top staging and the studding raised and set on 16-in. centers, using a light gauge for convenience in spacing. The first plate section is nailed to the door form and then to the first stud raised (Fig. 2). As soon as three or four studs are placed, light horizontal stays are tacked to them to stiffen the structure (Fig. 3).

When the door frame form is in place and carefully plumbed, no trouble should be found in bringing the plate and studs into position.

PLACING THE METAL

The ladder rods, which are ⅞-in. iron hooked at each end, are in place before the form is raised, and now a piece of pipe is placed vertically at either side of the door and engaged by the ladder rod hooks (Fig. 10).

The expanded metal comes in sheets usually 18″ wide and 8′ long, nine sheets to the bundle. The Kansas Station finds 24-ga. plain expanded metal a satisfactory material. The end of a sheet is passed through the door form and secured around the vertical pipe and then tacked to the inside of the studs with double-pointed tacks. The whole inside of the structure is lathed, lapping the sheets horizontally about ½″ and about 3″ at the ends. The edges should be wired together to prevent separation when plastering. Care should be taken to place the metal so that the slant of the meshes is up when looked at from the inside, as it holds the plaster better placed that way.

REINFORCEMENT

The metal lath reinforces the silo greatly but is not considered sufficient for safety, especially for large structures. Provision is made for greater strength by wrapping with wire after the inside plaster has been applied and studs removed. For convenience in anchoring the reinforcing, loops of wire are fastened around the vertical pipes at the doorway, spaced properly as indicated by Table 2. The table is based on No. 9 plain steel wire; if No. 12 wire is used double the number of strands. Silos larger than 16′ require another strand at the spacing indicated in the table for each 2-ft. increase in diam.

Before plastering, bolts should be placed head down in the plate, with large washers, not less than 10 ⅜-in. x 10-in. bolts being used for silos up to and including 16′ in diam. The bolts should be wired to the metal lath so as to be embedded easily in the mortar. Bolts should also be placed to attach chute or any other structures to be attached to the silo.

TABLE II—PROPER SPACING OF WIRE REINFORCEMENT FOR SILO 16′ DIAM.

Ft. from Top of Silo	No. of Strands of No. 9 Wire Required
0- 4	1 strand for every 24″
4- 8	“ “ 24″
8-12	“ “ 24″
12-16	“ “ 12″
16-20	2 strands for every 12″
20-24	“ “ 8½″
24-28	“ “ 6½″
28-32	“ “ 5″
32-36	“ “ 4″

INSIDE PLASTER SCRATCH COAT

The Bulletin says:

Material Required.—The mixture for the scratch coat consists of 1 part of cement, 2½ parts of sand, and 10% as much hydrated lime as cement (by weight). About 1 bu. of hair to every 300 sq. ft. of surface to be covered must be used in this first coat. For the plastering of a silo 16′ x 30′, about seven sacks of hydrated lime and five bus. of hair will be required. The lime should

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[1] *Agricultural Education*, May, 1912

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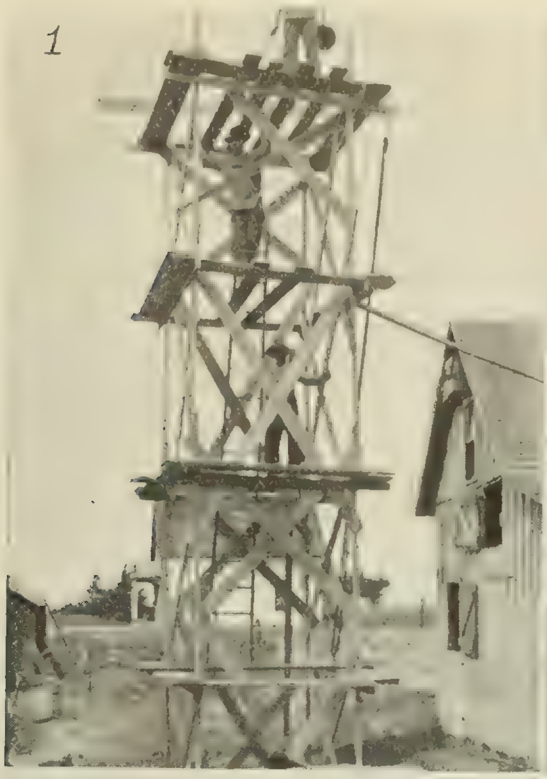

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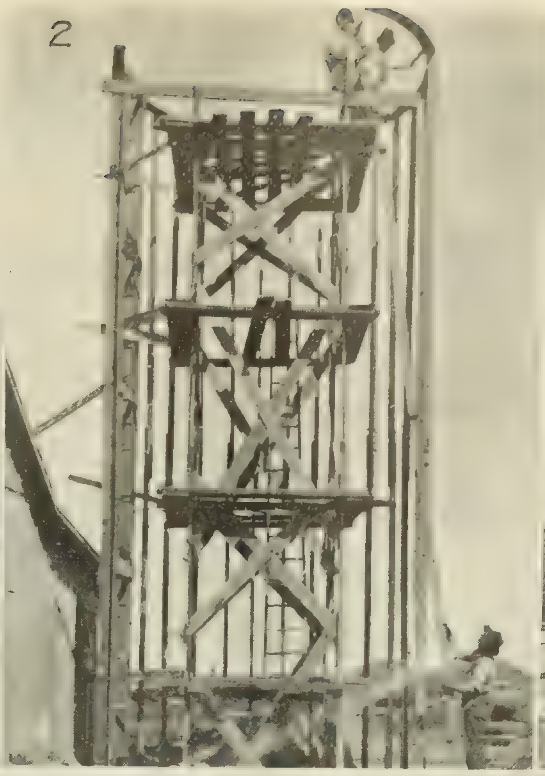

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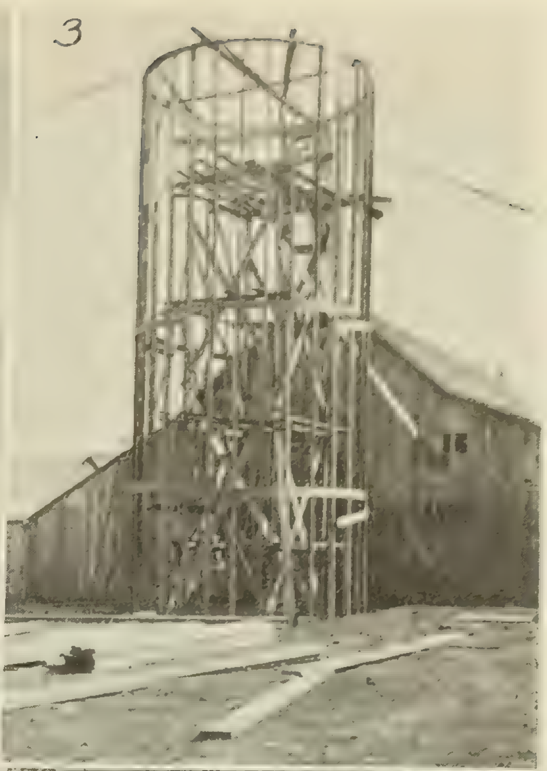

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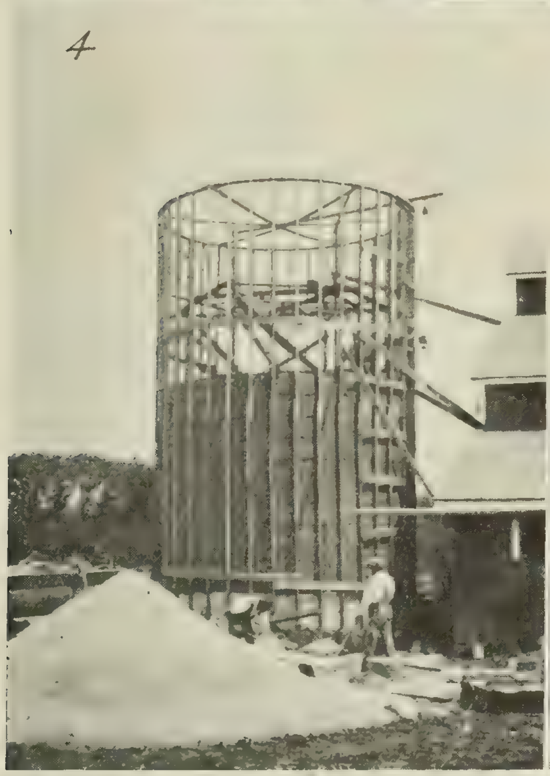

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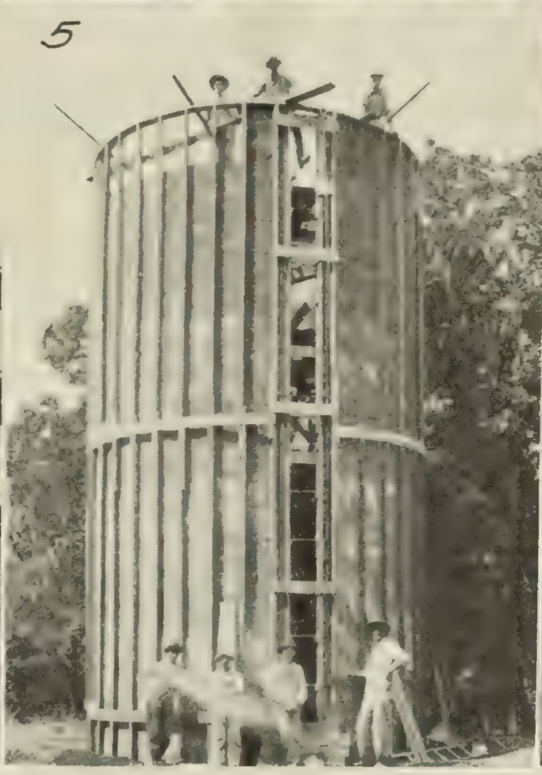

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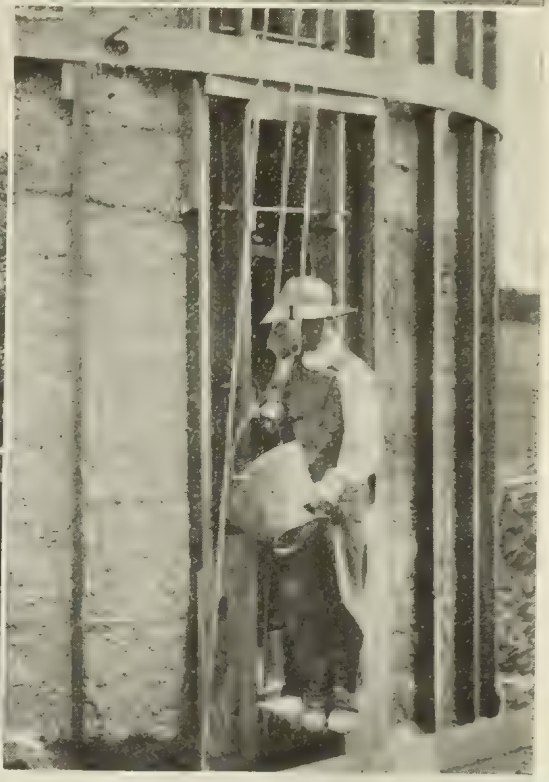

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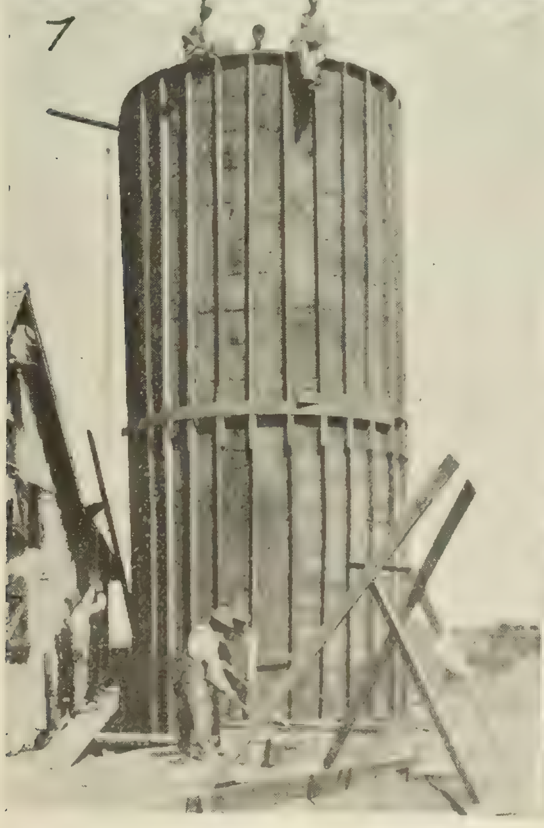

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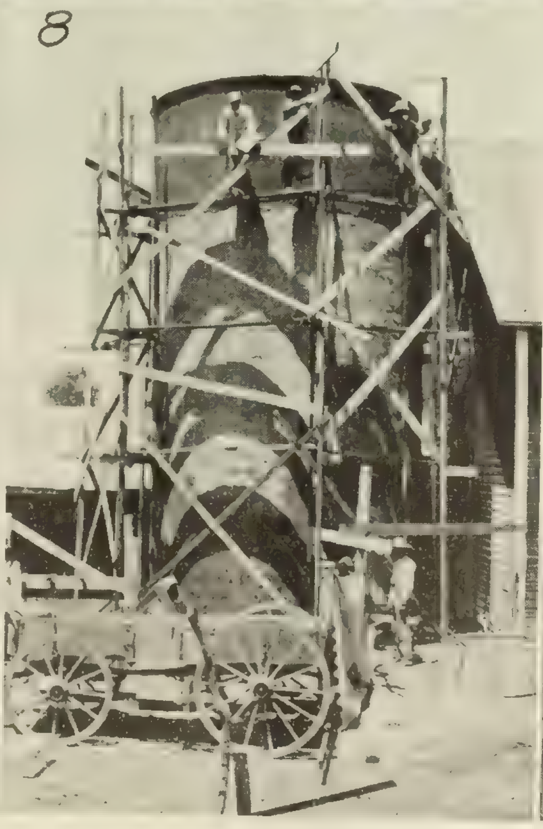

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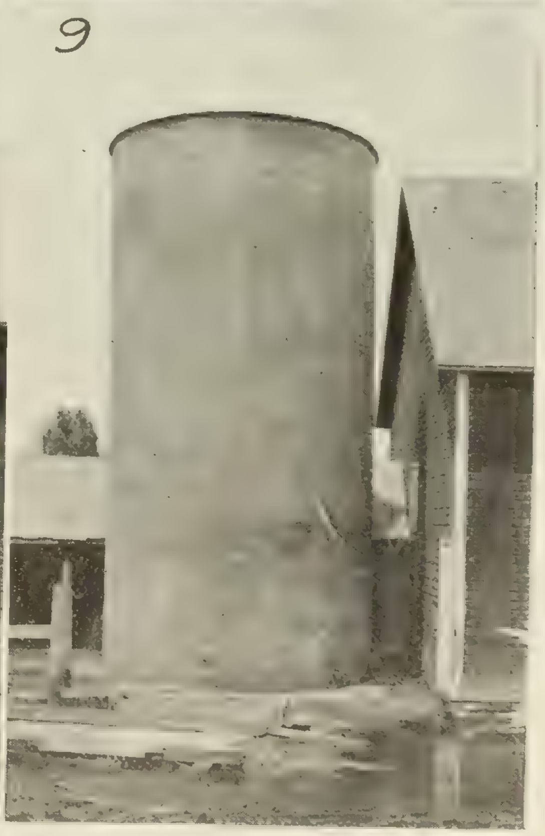

Fig. 1—Inside Scaffold
Fig. 2—Placing the Studding
Fig. 3—Ready for Lathing
Figs. 4-5—Applying the Scratch Coat

Fig. 6—Pouring the Door Posts
Fig. 7—Ready for Outside Scaffold
Fig. 8—The First Coat Outside
Fig. 9—Ready for Silage

be soaked up 10 hrs. or 12 hrs. before it is to be used. The hair should be thoroughly beaten apart on a barn floor, and after being soaked several hours should be carefully picked to pieces and worked into the lime putty which has been prepared. If care is used, the hair will be thoroughly mixed with the lime and the mixture can be added to each batch of the cement mortar as it is being prepared for use. It will take about 1½ pailfuls to each two-bag batch of mortar. It will be well for the plasterer to make some estimate as to the right amount of this to use in each batch, so as to have enough to use for the whole scratch coat. This coat will require about 13 two-bag batches of mortar for the 16-ft. x 30-ft. silo.

Mixing and Applying the Plaster.—Two good plasterers will be required and four tenders, two to measure materials and mix the mortar, one to carry and elevate it to the proper platform, and the fourth to receive the mortar on the platform and place it on the mortar-boards. This last man should do all the moving and shifting work, so that the plasterers may not be delayed at any time. In preparing the plaster, two good mortar boxes should be provided so that while one batch is being used the mixers may be measuring and preparing the second batch. * * * *

It will be necessary for the plasterers to supervise the mixing of the mortar, since it must be prepared exactly right in order that it may be properly placed on the walls. In preparing the scratch coat mortar, the lime and hair mixture, of course, is added and thoroughly incorporated with it. In putting on this coat, the plasterer should place an extra amount of plaster in the corner next the door post. This is necessary in order to prevent the concrete from leaking out of the door-post form when it is filled.

FILLING DOOR-POST FORMS

When the scratch coat is complete the door forms must be filled. See that the forms have not been sprung, and brace them thoroughly to the scaffold. The plasterers should have filled the crack where the lath enters the form. The front of the form should be cased up a section at a time and filled with rich concrete well spaded into place. A coal scuttle is convenient for this work (see Fig. 6). It is best to pour these posts at the end of a day so they can set over night and cause no delay. The narrow strips next the plaster should be removed before starting the next coat.

INSIDE PLASTER

Second Layer. Three coats of cement mortar 1:2½ should now be put on as rapidly as possible, "brooming" between coats to secure a good bond and keeping the work thoroughly wet. These three coats are here understood to form the second layer.

Finish Coat. The inside members of the door forms are now removed with care, as the concrete can still be injured by a blow or strain.

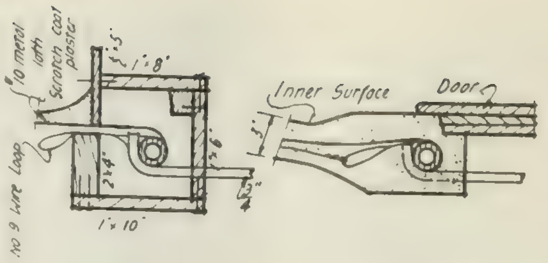

Fig. 10—Detail of Silo Door Form and Door

The last coat of plaster is mixed 1 part or 1½ parts screened sand to 1 part of cement, and is applied so as to form a smooth, dense, closely troweled coat and made to come flush with the inside of the door posts.

OUTSIDE SCAFFOLDING

The studding is now removed by carefully prying out the bottom of the studs, pulling out and down and freeing them from the structure. If left standing upright they are ready to be used as poles for the scaffold, as seen at Fig. 8.

Bill of Material for a Cement Metal-Lath Silo 14′ x 30′—Exclusive of Roof. Capacity, 93 Tons

Footing and floor the same as for a solid-wall silo of similar size.

Silo proper above foundation (3-in. wall):	
Sand	11⅔ cu. yds.
Cement	145 sacks
Hydrated lime	5 sacks
Hair	4 bu.
Expanded metal lath, 24 ga.	156 sq. yds.
No. 9 wire for reinforcement	100 lbs.
¾-in. gas pipe 30′ long	2 pcs.
¾-in. iron rods 2′ 8″ long	12 pcs.
2-in. flathead screws	2 gro.
16 d. nails	8 lbs.
8 d. nails	8 lbs.
4 d. nails	1 lb.
No. 11 double-pointed tacks	1½ lbs.
⅜-in. bolts 10″ long	10
⅜-in. bolts 4″ long	12
Lumber for permanent use:	
6-in. fir or cypress flooring for doors	220 ft.
Lumber 1 x 5 (or 6) cypress	100 lin. ft.
Door form lumber:	
1 x 6 selected	2 pcs. 14′ and 2 pcs. 16′
1 x 8 full width selected	2 pcs. 14′ and 2 pcs. 16′
Lumber for temporary use:	
Scaffold—	
2 x 4—16′	78 pcs.
2 x 4—12′	18 pcs.
⅜-in. x 6-in. (siding)	120 lin. ft.
1 x 5 (or 6)—18′	12 pcs.
2 x 8—7′	24 pcs.
2 x 6—12′	24 pcs.
1 x 6—12′	12 pcs.
Labor:	
First two days	
2 good carpenters.	
3 common laborers.	
Until finished	
2 good plasterers.	
4 common laborers.	

Bill of Material for a Cement Metal-Lath Silo 16′ x 30′—Exclusive of Roof, Capacity, 119 Tons.

Footing and floor the same as for a solid-wall silo of similar size.

Silo proper above foundation (three-inch wall):	
Sand	13½ cu. yds.
Cement	165 sacks
Hydrated lime	7 sacks
Hair	5 bu.
Expanded metal lath, 24 ga.	186 sq. yds.
No. 9 wire	150 lbs.
¾-in. gas pipe 30′ long	2 pcs.
¾-in. iron rods 2′ 8″ long	12 pcs.
16 d. nails	10 lbs.
8 d. nails	10 lbs.
6 d. nails	8 lbs.
4 d. nails	2 lbs.
No. 11 double pointed tacks	1½ lbs.
⅜-in. bolts 10″ long	10
⅜-in. bolts 4″ long	12
2-in. flathead screws	2 gross
Permanent lumber:	
1 x 6 cypress for plate	120 lin. ft.
6-in. fir or cypress flooring for doors	220 ft.
Door form lumber:	
1 x 8 full width sel.	2 pcs. 16′ and 2 pcs. 14′
1 x 6 selected	2 pcs. 16′ and 2 pcs. 14′
1 x 10 any length	60 lin. ft.
For temporary use:	
Scaffold—	
2 x 4—16′	78 pcs.
2 x 4—14′	24 pcs.
2 x 6—18′ (or 16′)	16 pcs.
1 x 6—12′	12 pcs.
2 x 6—12′	24 pcs.
2 x 8—8′	24 pcs.
⅜-in. x 6-in. (siding)	120 lin. ft.
Labor:	
First two days	
2 good carpenters.	
3 good laborers.	
Until fiinished	
2 good plasterers.	
4 common laborers.	

OUTSIDE PLASTER

At least two coats of exterior plaster are to be applied, giving a thickness of not less than 1″. The last coat should be darbied to leave a true wall and the surface hand-floated for a pleasing appearance.

It is important that these coats be applied rapidly, preferably by masons on each staging and that no stops occur until the work is complete, as otherwise the points of delay or stoppage will show disagreeable streaks.

The work should be kept wet and shaded if possible for at least a week.

Doors and roof can be constructed as desired.[2]

QUANTITIES AND COSTS

The silos built have cost not over $3.00 per ton capacity and in many cases less. Following are data condensed from the *Bulletin*. The silos from which the table is compiled were all erected in Kansas in 1910.

Table 3. Cost of Metal Lath Silos.

Cost of one silo, 14′ x 30′	$234.00
Average cost of 5 silos, 15′ x 30′	260.00
Average of nine silos, 16′ x 30′	277.55
Highest cost in this group	325.00
Lowest cost in this group	200.00
Cost of one silo, 16′ x 31′	229.00
Cost of one silo, 18′ x 34′	278.00
Cost of one silo, 18′ x 34′	296.00
Cost of one silo, 18′ x 37′	285.00

According to the Long Beach, Cal., *Telegram*, tests of California glazed cement pipe now used in the construction of the Long Beach sewer system have just been made and show excellent results. Broken pieces of 30-in. cement sewer pipe, immersed in water for a period of 24 hrs. were found at the end of that time to have absorbed of moisture less than 2% of their weight.

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[2] Concrete, July, 1915, and Aug. 1915

New Equipment, Methods and Materials:
New Tools with Which the Industry Works

This magazine will not publish "reading notices," so-called, for the benefit of advertisers. These pages are edited for the Reader, as are all other pages in "Concrete." Manufacturers are constantly producing new and better methods and developing old methods, materials and machines. The progress of the concrete field is measured by the development of its tools. All developments along these lines are of real interest and importance to men who want to improve the quality of their work, decrease its cost, increase its quantity. This department is for just that kind of Editorial material. We, therefore, welcome detailed announcements which will be of practical value to Readers. Under no circumstances will this magazine publish any announcement simply because an advertiser asks it, nor refuse publication because a non-advertiser asks it. Material must carry information of real consequence to the reader. All material will be edited on that basis regardless of the source from which it comes.—THE EDITORS.

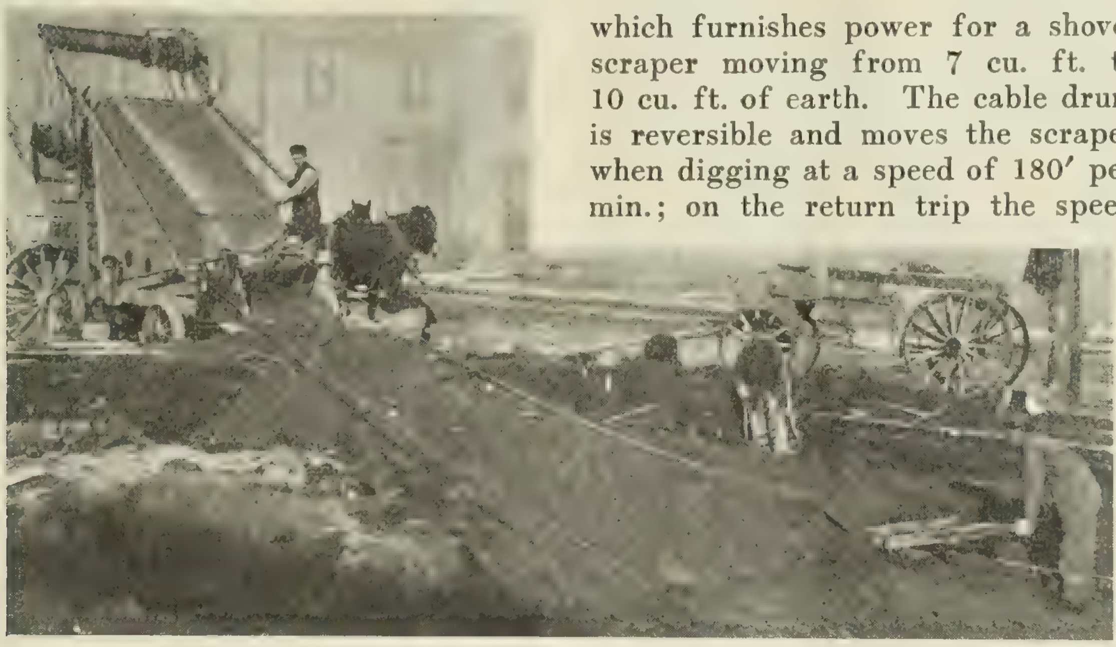

FIG. 1—DIGGING WITH THE ALBRECHT EXCAVATOR

The Albrecht Excavator and Loader

The combination excavator and loader[1] shown in the accompanying illustrations is an innovation. It fills the gap between team scrapers and hand shoveling and the steam shovel. As is well shown by the illustrations the machine and wagons do not enter the excavation. The excavator operates over a fan-shaped area and at a distance of 100′. Three positions of the machine along the front of a large basement will clear the whole area, with very little hand trimming.

The machine is driven by a 12-h. p. horizontal gasoline engine, which furnishes power for a shovel scraper moving from 7 cu. ft. to 10 cu. ft. of earth. The cable drum is reversible and moves the scraper when digging at a speed of 180′ per min.; on the return trip the speed is increased to 420′ per min. It is said that in operation a full scraper load per min. can be handled by the machine and two men.

The scraper when loaded is drawn into a skip, plainly shown in the illustrations; the skip swings up until it strikes the discharge spout, when the material is dropped into the wagon and the scraper at once returns.

While the machine will dig harder material than team drawn scrapers can, where very hard digging is encountered a plough can be hitched to the drag-line for loosening the soil.

The most common field for the excavator is likely to be basements for buildings but it is also proposed for use in road and grading work, for ditching and for back-filling. It is also used in stripping gravel banks and quarries and for loading gravel, broken stone or other material.

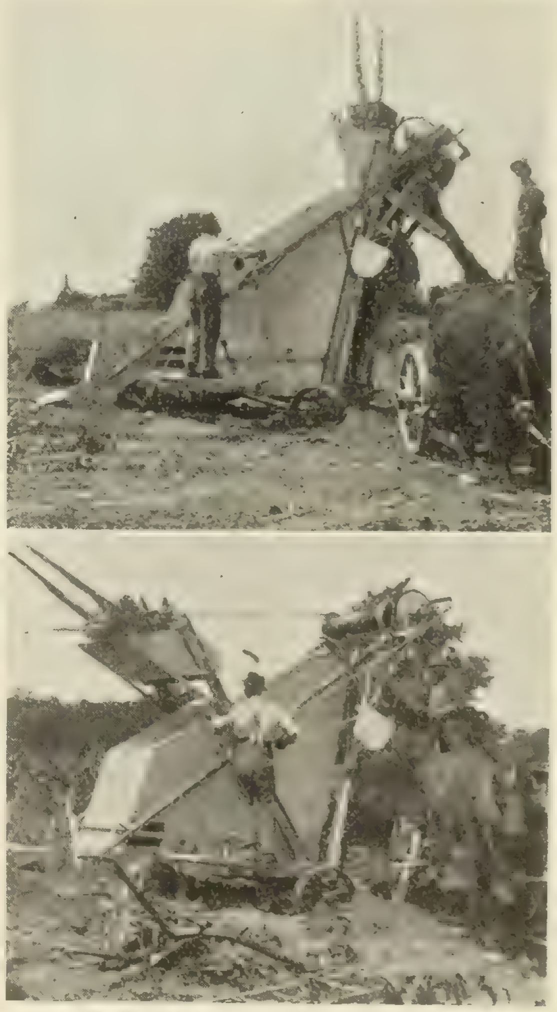

FIG. 2—LOADING THE WAGONS

Specification for the Application of Waterproofed Cement Stucco Integral Waterproofing Co., N. Y. C., paper, 3¼″ x 6″, 24 pp., illust. This publication discusses the mixing and the application of stucco and the use of "Star" waterproofing with this material.

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[1] T. L. Smith Co., Milwaukee

Improved Tools for Drilling Concrete

For some time hand tools for drilling concrete have been available. The Rapid-Fire drill[1] which has previously been described by this magazine, has been redesigned and equipped with devices for securing more work with less fatigue to the operator.

Among the improved features of the new model is the adjustment screw for regulating the power of the blow exerted upon the drill and the new extension spring operated over the yoke which straddles the main shaft at the rear of the plunger.

SECTIONAL VIEW OF RAPID-FIRE DRILL
RAPID-FIRE FLOOR STAND

The floor stand, as illustrated, is so designed that the operator is conveniently seated on the platform and by a slight forward or backward movement on the platform the drill point is inserted or withdrawn from the hole, with a rocker motion. This stand is particularly useful where a great number of holes must be drilled on given centers as in the floors of auditoriums for fastening seats. When the holes are marked the operator can without leaving the seat slide the point to different positions where drilling is required.

In order to improve the efficiency of the tool when drilling in ceilings a telescopic sectional adjustable stand is furnished. The drill is forced forward by means of a powerful spring.

Unit Steel Forms for Concrete Walls and Floors

Metal forms were recently used on a reinforced concrete building constructed by Collins Bros. at Rock Island, Ill.

The steel form used on this building is a special plate known as lap sheeting.[2] The units consist of L-shaped plates of light pressed steel 36″ long and 6¼″ on the face; the short side of the angle which stiffens the plate is 1¾″ long.

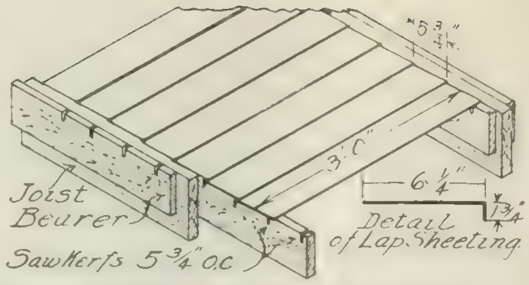


FIG. 1—DETAIL OF STEEL SHEETING

Fig. 1 shows the method of placing. The supporting joists are spaced at 3-ft. ½-in. centers and shored. Bearers of 1-in. by 6-in. lumber are saw kerfed at 5¾-in. centers to receive the short leg of the angle, leaving a ½-in. lap for each plate. These bearers are nailed to the supporting joists.

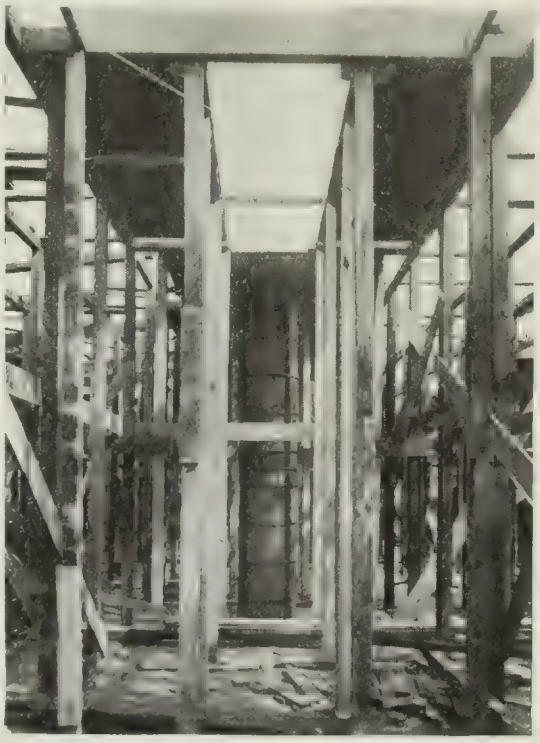


FIG. 2—WOOD FRAMING IN PLACE, SHEETING PARTLY LAID

When the concrete has taken the initial set the bearers can be removed, freeing the plates for further use. The illustrations show distinctly the use of the plates. Fig. 2 shows the framing used and in the background a steel column form in place. The column cap joins the floor with a square section as shown at Fig. 3, which makes the connection a simple matter.

FIG. 3—FORMS REMOVED, SHOWING TEXTURE OF CEILING

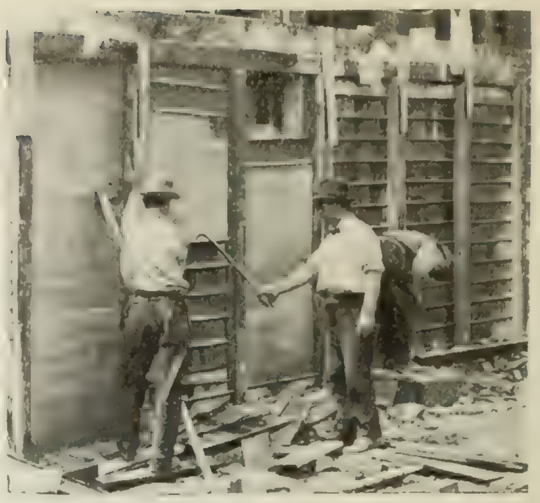


FIG. 4—STEEL SHEETING USED FOR WALL FORMS

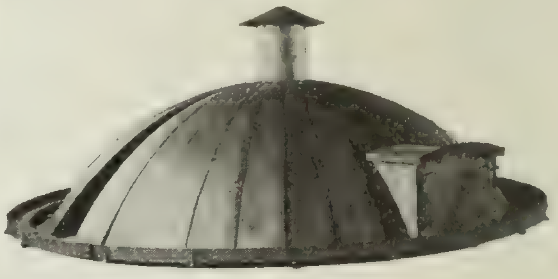
Fig. 3 shows the appearance of the ceiling after stripping the forms; the ridges left are regular and the surface of the concrete dense and very smooth.

At Fig. 4 the same forms are shown in place and the texture of the finished wall is well shown.

Form for a Dome-Shaped Silo Roof

Several forms for the construction of concrete silo roofs are now on the market.

The illustration shows a form[1] for building a dome-shaped roof that is very attractive. The construction of the form is well shown in the illustration. It is said to be very rigid when in place and easily set up and removed.


THE REICHERT ROOF FORM

A Silo Form With New Features

A silo form has been developed[2] which incorporates some new ideas. The support is a light steel tower of angle iron and carries the forms and staging. It is supplied in convenient lengths and provided with suitable metal ledgers and tension rods.

The forms are supported by channel iron arms which are arranged to be raised by means of a powerful screw-jack at the center of the form. This jack is carried on channel irons supported by the steel tower. From

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[1] Diamond Expansion Bolt Co., N. Y. C.
[2] Blaw Steel Constr. Co., Pittsburgh

[1] Reichert Mfg. Co., Milwaukee
[2] J. F. Webb, Ypsilanti, Mich.

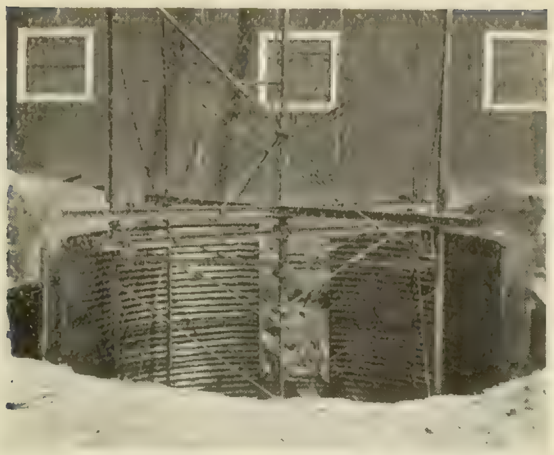


FIG. 1—SILO FORM PARTLY IN PLACE

Note construction of tower and corrugated iron stiffening for plate

this support is also carried a derrick arm for hoisting concrete.

The forms themselves are of unique construction. Two tiers are used, each consisting of several sections for convenience in handling. Each section consists of a sheet of galvanized iron, backed with a sheet of corrugated iron bent to the proper radius. The edges are suitably reinforced with steel angles.

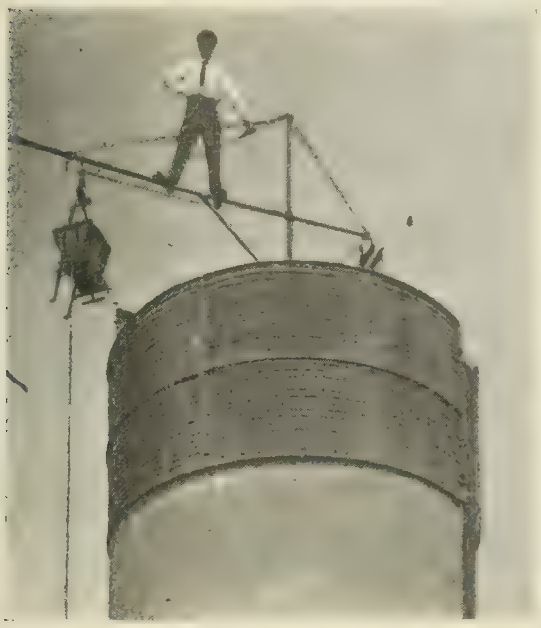


FIG. 2—WEBB SILO FORMS

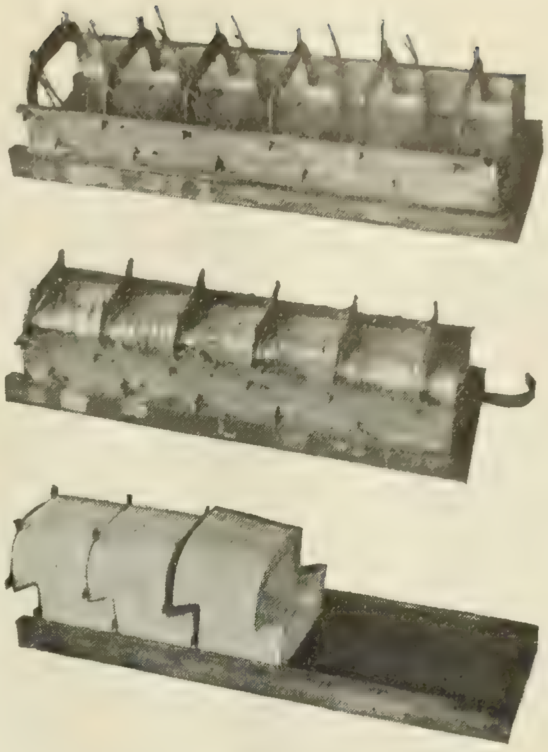
Note construction of automatic dump bucket

This construction results in a form that, while light, is exceptionally rigid.

The bucket used for hoisting concrete is worthy of mention. It is of the drop-bottom type and arranged to dump automatically when lowered against the top of the form. The construction of the derrick allows it to be lowered at any desired point on the circumference of the silo.

Interlocking Sectional Concrete Culvert

The Hall interlocking concrete culvert[1] is molded in a shop, five inside sections being cast at one time, and hauled to place of use complete with end-blocks or head-walls, where it is said that under ordinary conditions it can be set in place by two men in one day. All sections, including head-walls, are securely interlocked without the use of metal rods, bolts or hooks. The joints are intended to take care of frost action and expansion and contraction.



FIGS. 1, 2 AND 3.—TOP TO BOTTOM

The distributors assert that this reinforced concrete culvert can be manufactured locally and installed at a cost not to exceed that of metal culverts and, in most cases, for less money.

Some of the steps in manufacture are shown in the accompanying illustrations. In Fig. 1 the side and the bottom forms with the dividing molds are in place and the bottom of the form partly filled, with reinforcing wires in place. Fig. 2 shows the core in place ready to complete the placing of the concrete. Fig. 3 shows the sections after removal of core and side forms.

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[1] O. S. Hall, Patentee: Schulz & Hodgson, distributors, Assn. Bldg., Chicago

A Concrete Hoist of Simple Construction

The problem of handling concrete on large operations has been well worked out, but much room remains for more economical methods for use on the smaller jobs.

The quantities of concrete used on these jobs are not large enough to warrant the use nor the installation of elaborate equipment.

The device here described was developed by J. H. & R. Shannon Co.[1] and has been used successfully by that company.

The track, details of which are

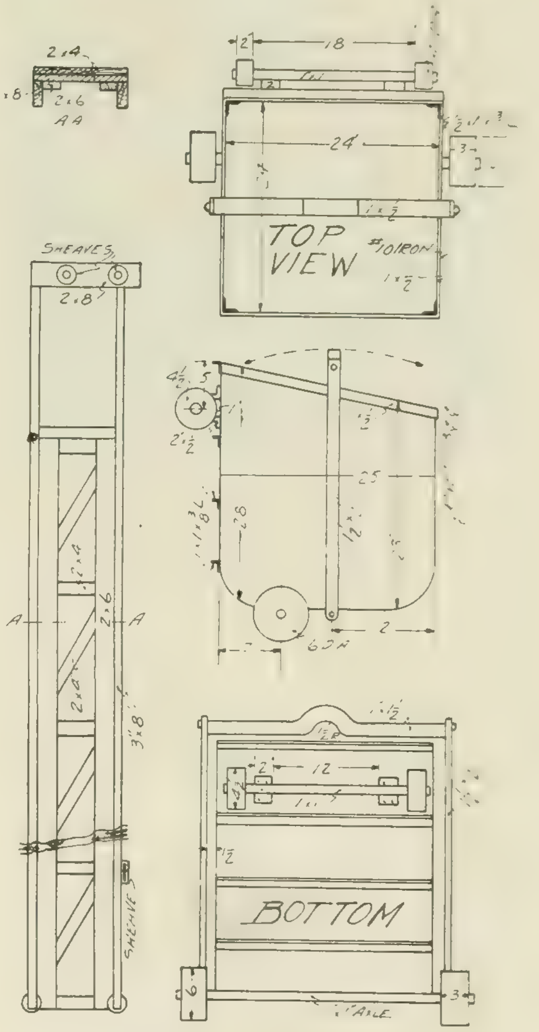

FIG. 1—DETAIL OF TRACK AND SKIP

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[1] Jersey City, N. J.

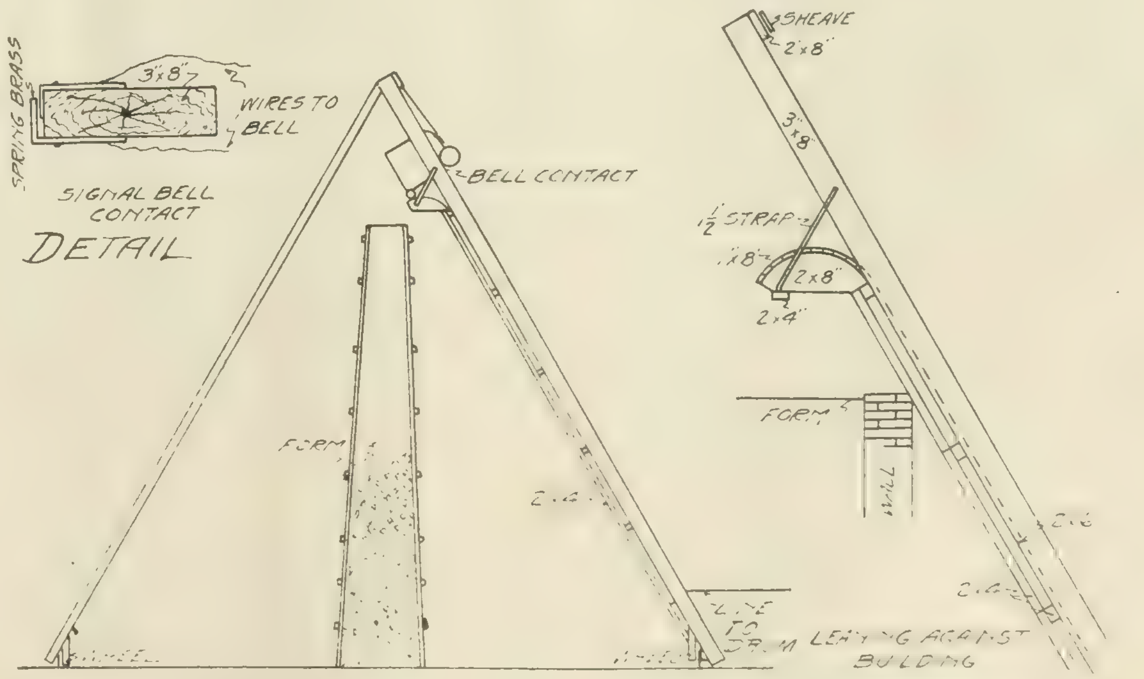


FIG. 2—ELEVATOR IN POSITION STRADDLING FORMS AND AGAINST BUILDING
Note detail of signal bell

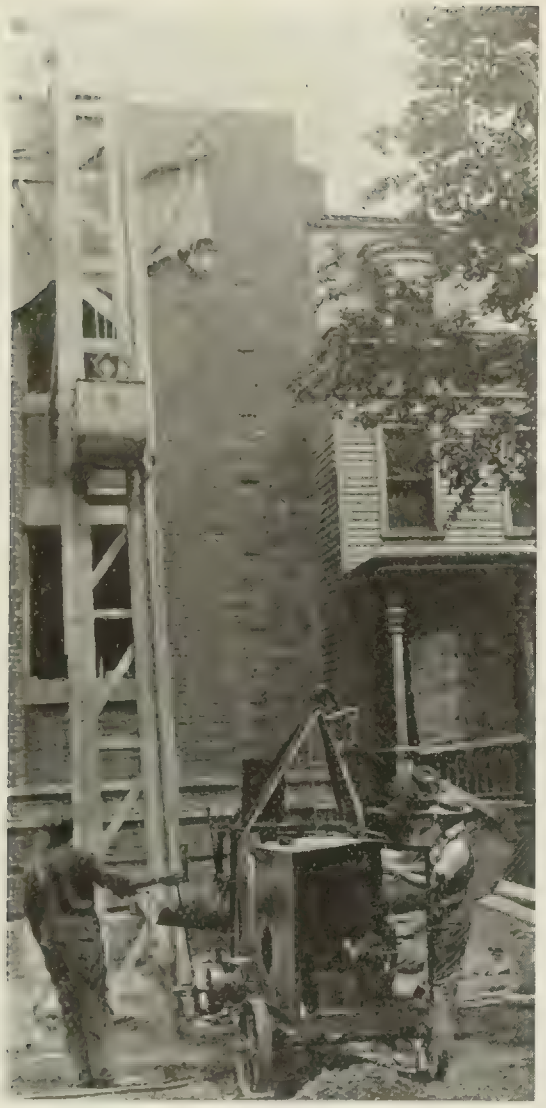


Fig. 3—Elevator in Use

Note that mixer dumps directly into skip. Hoisting cable lead to drive by snatch block not shown

shown at Fig. 1, is built in 12-ft. sections, which are spliced as required. The 5-cu. ft. skip is built of sheet steel, as shown at Fig. 1. It is said that the cost of the outfit complete is less than for the tower alone which was formerly used.

The elevators can be used either leaning against a building or forms can be straddled, as shown at Fig. 2. By mounting the hoist on rails it is easily moved as desired.

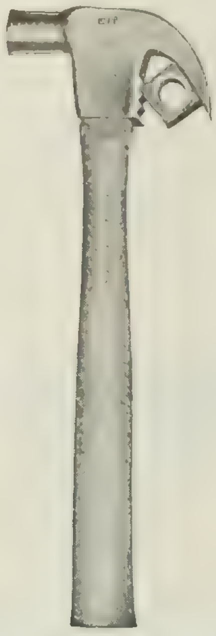
The elevator was used in connection with a combination mixer and hoist[2], but if desired could have been operated by a separate hoist.

In order to enable the stop to be made at the right instant brass contact plates, as shown in the detail, Fig. 2, are connected with an electric bell, so that the skip automatically signals the operator when it is in dumping position.

A saving of 40 cts. to 50 cts. per cu. yd. has been made in light work, such as walls, piers and floors, by the use of the equipment as compared with the tower and spouting system previously used. A 35-ft. rig has been set up and placed in operation in 45 min. after its arrival on the job.[3]

A Combined Hammer and Wrench

Combination tools are not usually looked upon with favor by the mechanic.



E-I-T Hammer-Wrench

An exception to prove the rule seems to have been devised in a combination hammer and wrench as illustrated.[1]

The balance and "feel" of the hammer are not impaired and the notches formed on the eye of the tool are out of the way until needed, when the hammer is instantly available as a wrench. There is no adjustment needed and the range includes all nuts commonly used about concrete equipment and form work. This tool is known as the E-I-T Hammer Wrench.

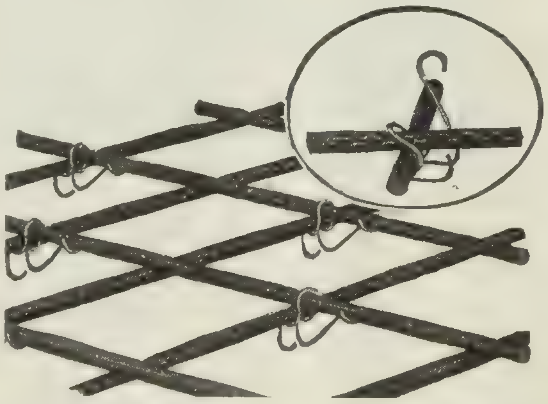


Fig. 1—Ty-Chair for Securing Reinforcing Bars

Time-Saving in Placing Reinforcing

The importance of placing reinforcing rods properly and maintaining them in exact position without excessive cost has led to the development of a large number of special devices for this work.

The illustrations show three[2] ingenious devices as follows:

Fig. 1 shows a combined clip and chair arranged to secure two rods of any size together and keep them the proper distance from the form. Its action is well shown in the enlarged view.

Fig. 2 shows a similar device, which is somewhat more quickly placed, but is not provided with a chair. It is adapted for use where extreme rigidity is not essential.

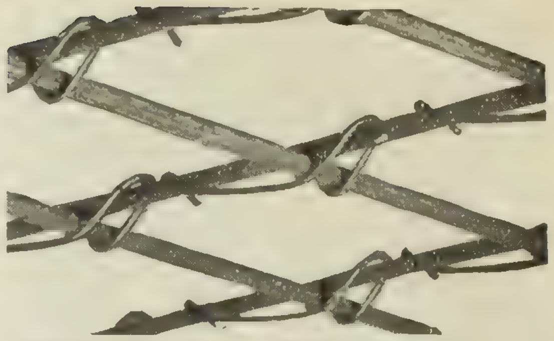


Fig. 2—Bar-Ty, a Convenient Clip

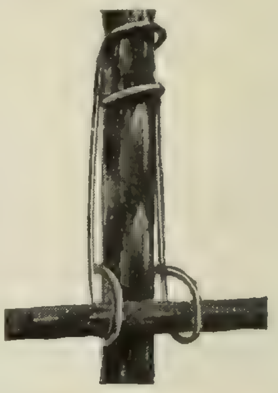
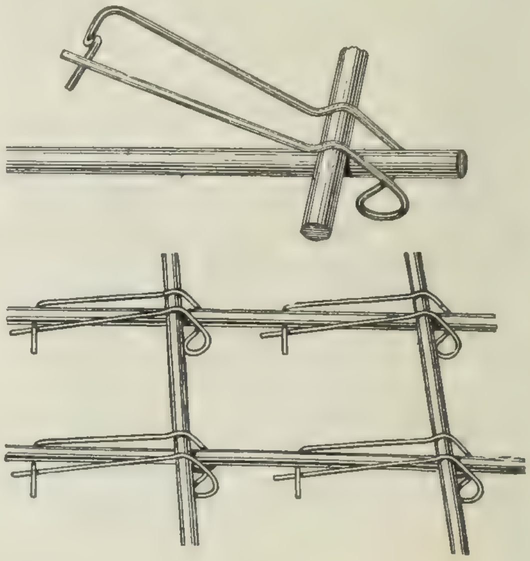


Fig. 3—The Bar-Ty As Used for Connecting Horizontal and Vertical Rods

Fig. 3 illustrates a clip designed to tie horizontal bars to vertical bars. Its use is said entirely to overcome slipping of the horizontal members and greatly decrease the time necessary to place this class of material.



The Symons Bar Tie

Symons Bar Tie and Chair

Tying reinforcing bars properly and supporting them so that they will be at the proper distance from the forms has been given a good deal of thought.

Tying by hand by means of wire is slow and expensive. A solution of the problem is found in the use of the Symons bar tie.[1] As shown by the illustration, it is snapped over the bars in an instant and being made of spring wire holds them firmly. The tie is furnished with or without the supporting loop illustrated.

Plymouth Locomotives—The J. D. Fate Co., Plymouth, Ohio, paper, 6″ x 9″, 24 pp., illust. The use of the gasoline locomotive which is adapted to narrow and standard gauge tracks is described, together with a description of mechanical features of the equipment are given in this catalog.

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[2] Am. Cement Mach. Co., Keokuk, Ia.

[3] A somewhat similar hoisting rig was described in CONCRETE, Apr., 1914, p. 200; see also CONCRETE, Jan., 1914, p. 3

[1] Eureka Improved Tool Co., Inc., N. Y. C.

[2] Concrete Steel Co., N. Y. C.

[1] Symons Clamp Co., Kansas City, Kan.

Trade Publications

"The Big Lesson of this Fire," said Edison—Trussed Concrete Steel Co., Youngstown, Ohio. Paper, 12¾" x 10", 8-page folder, illust. A graphic description of the Edison fire, also tests made on steel sash for the new Edison plant.

Hy-Rib—Trussed Concrete Steel Co., Youngstown, Ohio. Paper, 7½" x 5½", 144 pp., illust. The 13th edition of the Hy-Rib handbook adds several new features to that valuable publication. As in previous editions the various types of expanded metal products are described and their uses illustrated from diagrams and photographs. The addition by this company to its products of a line of pressed steel beams, studs, furring, etc., makes a chapter on these new items a matter of special interest. The Hy-Rib book is a leading example of publications now so often distributed by manufacturers which far exceed the functions of a mere catalog and which, while they may be had for the asking, are a valuable addition to any concrete reference library.

Gemco Appliances—Gemco Mfg. Co., Milwaukee, Wis. Paper, 8½" x 5¾", 12 pp., illust. This catalog describes the Gemco line of contractor's equipment. This company specializes on an adjustable metal shore which is used in connection with various other devices for reducing form work cost. This catalog should be in the hands of every contractor who wishes to keep abreast of developments in the line of new equipment.

Automatic Concrete Mixers—Automatic Concrete Mixer Co., Providence, R. I. Paper, 9" x 6", 32 pp., illust. This catalog describes the so-called gravity mixer and shows methods of installation by diagrams and photos. It is a very clean presentation of the facts about a mixer that mixes without power.

The "Wells Light"—The Alexander Milburn Co., Baltimore, Md. Paper, 9¼" x 6¼", 4-page folder, illust. This folder describes the Wells Lights and heating equipment. It is noted that in the future the Wells products will be handled by the Alexander Milburn Co., Baltimore, Md.

Bonanza Cement Tile Roofing—American Cement Tile Mfg. Co., Pittsburgh, paper, 9¼" x 6¼", 40 pp., illust. This booklet is particularly well printed in two colors and shows abundant evidence that Bonanza tile roofing is good roofing material for industrial plants of all kinds. One especially large 4-pp. spread shows extensive work done by this company at the railroad terminals at the Panama Canal. It also illustrates the various forms of tile and gives tests showing their strength, and their resistance to fire.

Lawson Loop-Line Tramways—The Ambursen Co., N. Y. C., paper, 10" x 7", 46 pp., illust. This is a loose-leaf catalog describing a new and unique system of conveying loose material of any kind. A system of tramways described in this book, designed to minimize wear on cableways, provides for handling the material in a large number of small cars running on four wheels, thus distributing the wear and lengthening the life of the equipment. The book is profusely illustrated and will prove not only interesting but of great value to anyone having to deal with short-haul problems in moving gravel, clay, coal, etc.

Rock-Ore and Gravel Handling Machinery. Catalog 254—Smith Engrg. Co., Milwaukee, paper,, 9" x 6", 46 pp., illust. This catalog describing the well-known Telsmith line of gravel-handling machinery is gotten up in an interesting way. Many illustrations show crushers, screens and conveying equipment.

Cement Tools, House Numbers and Letters, Catalog No. 15—Smith & Holtum Mfg. Co., Clinton, Wis. Paper, 8¾" x 3¾", 42 pp., illust. An attractive catalog of concrete workers' tools in great variety.

Patented Combined Centipede Motor Truck and Tractor—Phoenix Mfg. Co., Eau Claire, Wis. Paper, 10¼" x 7¾", 12 pp., illust. This catalog describes a gasoline-driven tractor of the caterpillar type. It will interest those having to solve haulage problems.

Horse Power Chart for Power Transmission Machinery, Bulletin Ka.—Mesta Machine Co., Pittsburgh, Pa. Paper, 9" x 6", 4-page folder. This bulletin presents a chart from which the variables for rotating parts of machinery may be determined.

Parker's Expansion Bolt—Parker Supply Co., N. Y. C. Paper, 6¼" x 3¼", 8-page folder, illust. Parker expansion bolts and toggle bolts are well illustrated and described in this instructive folder.

Indicating Hand Level—The Toledo Indicating Level Co., Toledo, Ohio, paper, 19" x 25", two-page folder, illust. This attractive folder illustrates in colors, full size, a new level for general use. This level is unique as it shows instantly the exact amount per ft. the work is out of level.

Type A & Type C Recording Pyrometers, Bulletin No. VIII.—Thwing Instrument Co., Philadelphia. Paper, 10¼" x 6½", 50 pp., illust. The various types of Thwing recorders are fully described and illustrated. Several specimen record charts are also given, as well as complete price list.

The Whalen Form—The Whalen Form Co., Syracuse, N. Y., 10¾" x 5", paper, 12 pp., illust. This folder shows photographic views of the Whalen forms for concrete culvert construction. Standard culverts used by the State Highway Department of New York are also shown.

Schmidt's Solid Brass Concrete Sidewalk Brands—Geo. T. Schmidt, Chicago, paper, 9" x 6", 4 pp., illust. This folder shows a few specimens of the Schmidt solid brass concrete sidewalk brands, dater for concrete work, rotary stamps for concrete sewer pipe and block, bronze name plates, etc.

Worth Studying — Wallace Supplies Mfg. Co., Chicago, paper, 6¼" x 3½", 8 pp., illust. This folder describes briefly the several sizes and types of Wallace hand power bar benders for reinforcing bars.

Dull's Improved Tubular Washer for Sand and Gravel—The Raymond W. Dull Co., Chicago, paper, 10" x 6¾", 8 pp., illust. This folder describes the construction and operation of the Dull improved tubular washer for sand and gravel. Several sizes of screens are illustrated.

The Circular Storage System—Link-Belt Co., Chicago, Ill. Paper, 9" x 6", 4-page folder, illust. This bulletin discusses the use of a locomotive crane for storing materials.

Specifications and Directions for Use of Keene's Cement—The Best Bros. Keene's Cement Co., Medicine Lodge, Kans. Paper, 9" x 5", 28 pp. Substantial and well printed in two colors, describing the manufacture and use of Keene's cement. Complete specifications for its use on various kinds of work are given. As a handbook on Keene's cement it is worthy of a place in your reference file.

Ellipse Concrete Stave Silos—Ellipse Concrete Stave Silo Co., Kansas City, Mo. Paper, 11" x 8", 4-page folder, illust. This folder describes a new style stave and points out its many good features. In view of the increasing popularity of the stave silo this folder is well worth having.

General Catalogue—Bucyrus Co., South Milwaukee, Wis. Paper, 9" x 6", 48 pp., illust. This catalog describes the Bucyrus line of steam shovels, drag-line excavators and other contractors' equipment. It is profusely illustrated and an interesting booklet on this subject.

The Duro Silo—C. C. Fouts Co., Middletown, Ohio. Paper, 9" x 6", 20 pp., illust. This publication describes the use of sheet metal in silo construction. The Duro silo roof and silo chute are items that make this catalog worthy of a place in every concrete silo contractor's file.

The Dull Drag Line Excavator for Digging Loose Materials—The Raymond W. Dull Co., Chicago, paper, 10" x 6¾", 16 pp., illust. This folder describes the construction and method of operating the Dull drag line excavator. Several typical installations are shown in detail.

Efficiency Rod Bender—Electric Welding Co., Pittsburgh, paper, 3½" x 6", 6-pp. folder, illust. In this folder is described the Efficiency bar bender, with a list of prominent contractors who are using it. A combination chair and rod lock is also featured.

The "Crescent" Power Brick Machine—Raber & Lang Co., Kendallville, Ind., paper, 9¼" x 6¼ ",4 pp., illust. This booklet considers the principles involved, the frame, tamps, sprockets and chains used in constructing the Crescent power concrete brick machine. Condensed specifications are given as well as list prices.

Shop-Fabricated Reinforcement—Booklet No. 1. The Shop-Fabricated Reinforcement Co., Cleveland, paper, 8½" x 4¼", 16 pp., illust. This neat pamphlet introduces a new type of factory-made reinforcing units. New fabrication details of unique design and undoubted strength and economy make this publication of unusual interest to the designer and to the contractor.

Johnson Photomicrographic Apparatus—A New Means for Testing Concrete—Bausch & Lomb Optical Co., Rochester, N. Y., paper, 9¾" x 6½", 16 pp., illust. This catalog describes in detail the apparatus needed for the microscopic study of concrete and for making micro-photographs. It is well printed and has numerous clear illustrations.

Marbleoid, The Universal Flooring for Modern Buildings—The Marbleoid Co., N. Y. C., paper, 9¾" x 7", 24 pp., illust. This attractive booklet illustrates many installations of Marbleoid flooring and gives information as to the facilities of the company for executing work in various localities.

Composition Flooring — By H. M. Hooker, Reprinted from the Proceedings of the Engineers' Society of Western Pennsylvania. Paper, 9" x 6", 58 pp., illust. This is a valuable treatise on flooring with particular reference to the so-called composition flooring. It does not give trade formulas, but it does give a great amount of information to the architect or to the builder.

Description of Exhibits of U. S. Steel Corporation and Subsidiary Companies—U. S. Steel Corporation, N. Y. C., paper, 10¼" x 7", 56 pp., illust. This pamphlet describes in detail the exhibits of the U. S. Steel Corporation and its subsidiary companies, among which are the Am. Steel & Wire Co. and the Universal Portland Cement Co. The book is a complete guide to these exhibits, which cover about 4,200 sq. ft. of floor space.

Weber Subterranean Pumps, Industrial Types—Weber Subterranean Pump Co., N. Y. C., paper, 9" x 6", 32 pp., illust. This well printed and illustrated catalog describes the Weber line of pumps. These pumps are placed under water in the well and are operated by air pressure.

Building Construction—Stone & Webster Engrg. Corporation, Boston, Mass., board, 5¾" x 7½", 38 pp., illust. This booklet is a wonderfully perfect piece of printing. It illustrates and briefly describes some of the important structures constructed by this well known firm.

Koehring Mixers — Koehring Machine Co., Milwaukee, paper, 19" x 12½", two-page folder, illust. This attractive three-color folder stimulates interest in the Koehring mixer and suggests the value of the Koehring large catalog, previously mentioned in this department.

The Harris Valveless Engine—Southwark Fdry. & Mach. Co., Philadelphia, paper, 8¾" x 11¼", 14 pp., illust. A very instructive loose-leaf catalog describing the Harris valveless gasoline engine of various types.

O. K. Tile—The Vetter Constr. & Development Co, Chicago, paper, 5½" x 3½", six-page folder, illust. The concrete roof tile has many desirable qualities. This folder presents the advantages of using this material.

Concrete Posts and How to Make Them—D. & A. Post Mold Co., Three Rivers, Mich., paper, 6" x 9", 32 pp., illust. This neat pamphlet is more than a catalog. It contains much information of value to the post manufacturer, in addition to a clear description of the equipment it is designed to sell.

Farm Drainage — Marquette Cement Mfg. Co., Chicago, paper, 3¼" x 6¼", 16 pp., illust. A concise statement of the benefit to the farmer of land drainage. A handy book of facts for the pocket of the tile manufacturer.

Instructions for Installing and Operating "Chicago Pneumatic" Class N-SO Fuel Oil Driven Compressors—Chicago Pneumatic Tool Co., Chicago, paper, 6" x 9", 24 pp., illust. Gives clearly defined suggestions for running these compressors with the minimum amount of trouble.

The Cornelius Simplicity Adjustable Cement Step Form—The H. D. Cornelius Co., Indianapolis, paper, 5" x 7", 8 pp., illust. This folder illustrates and describes devices which are intended to reduce greatly the cost of step building and which are adapted to use on other details in construction work.

The Crist System of Adjustable Forms for Concrete—Crist & Stukenberg, Kansas City, Mo., paper, 5¾" x 8½", 12 pp., illust. The support of floor and beam forms is a problem worthy of much careful attention. This publication describes devices said to effect large savings in this work.

The Maney Four-Wheel Scraper—The Baker Mfg. Co., Springfield, Ill., paper, 6¼" x 9¼", 14 pp., illust. The advantages of a more efficient machine than the slip or two-wheeled scraper are described in this catalog.

Symons Disc Crusher — Chalmers & Williams, Inc., Chicago Heights, Ill., paper, 7" x 9", 28 pp., illust. In this bulletin the Symons disc crusher is described in detail.

Rock Crushing Equipment—Chalmers & Williams, Inc., Chicago Heights, Ill., paper, 7" x 9", 28 pp., illust. In this catalog are presented illustrations and descriptions of the bronze ball gyratory rock crusher with other devices needed to equip rock crushing plants.

Concrete Roads; Modern Methods—The Heltzel Steel Form & Iron Wks., Warren, Ohio, paper, 8" x 10¾", 16 pp., illust. The steel form for road and curb work has been developed to a high degree of efficiency. The catalog describes this equipment as constructed by the above named firm.

The Baute Automatic Tamper — The Baute Concrete Machy. Co., Benton Harbor, Mich., paper, 7" x 9", 12 pp., illust. The Baute block and brick machine and the Baute automatic tamper are well described in this publication.

Hauling Equipment for Road Construction—Orenstein-Arthur Koppel Co., Koppel, Pa., paper, 6" x 9", 32 pp., illust. This substantial catalog describes in moving picture style the use and construction of Koppel cars, locomotives and track, with particular reference to road building. A valuable feature is a glossary of accepted road terms and other general information.

Tycos Pyrometers — Taylor Instruments Companies, Rochester, N. Y., paper, 3½" x 6", 38 pp., illust. A pocket-size catalog of apparatus for measuring high temperatures.

Current Prices — Concrete Materials □

Portland Cement—The cement market is still below normal, but the demand has increased during the past month, through prices show little change. Prices given are f. o. b. cars at points named, including cloth sacks, for which, in general, 40 cts. per bbl. (4 sacks) is refunded on return in good condition. Prices per bbl. (including 4 cloth sacks) are as follows: Boston, $1.66; New York, $1.42; Chicago, $1.51 to $1.56; Pittsburgh, $1.56; New Orleans, $1.63, on dock; Memphis, $1.80; Cleveland, $1.64; Detroit, $1.65; Indianapolis, $1.64; Columbus, $1.64; Cincinnati, $1.64; Toledo, $1.64; St. Louis, $1.50; Milwaukee, $1.63; Minneapolis and St. Paul, $1.78; Duluth, $1.91; Peoria, $1.59; Cedar Rapids, $1.70; Davenport, $1.60; Kansas City, $1.53; Omaha, $1.53; Spokane, $1.75; Seattle, $2.40; Portland, Ore., $2.40; Tacoma, $2.40.

Crushed Stone—1½-in. stone, prices per cu. yd., f.o.b. cars in carload lots, unless otherwise specified. Boston, 80 cts. per ton at the quarry; New York, 90 cts. in full cargo lots at the docks; Chicago, $1.15; Spokane, $1.00; Portland, Ore., $1.15; Seattle, $1.50.

Gravel—Prices given are per cu. yd. f.o.b. cars in carload lots unless otherwise noted. New York, 80 cts. in full cargo lots at docks; Chicago, $1.15; Spokane, $1.00; Portland, Ore., 85 cts.; Seattle, 75 cts.; Tacoma, 75 cts.

Sand—Prices are per cu. yd. f.o.b cars in carload lots unless otherwise indicated. New York, 50 cts., full cargo lots at docks; Chicago, $1.15; Spokane, 75 cts.; Seattle, 75 cts.; Portland, Ore., 85 cts.; Tacoma, 75 cts.

Reinforcing Bars—The demand for reinforcing bars is more active of late, but orders continue to be taken on a basis of delivery in five or six weeks, owing to the demand for large steel bars. The general tendency of the market is that deliveries will be made on a basis of $1.35 per cwt., Pittsburgh, with prevailing extras for bars under ¾" or base. The following are quotations on base bars per 100 lbs., for mill shipments from other points, f. o. b. cars: New York, $1.519; Philadelphia, $1.509; Chicago, $1.539; Spokane, $2.05; Portland, Ore., $1.85; Seattle, $1.85; Tacoma, $1.85; San Francisco, $1.70.

Shipments from stock are being made at the following prices per cwt. f.o.b. New York, $1.90; Philadelphia, $1.80; Buffalo, $1.95; Cincinnati, $1.85; Cleveland, $1.90; St. Louis, $1.80; Chicago, $1.75; St. Paul, $1.85; Spokane, $2.35; Portland, Ore., $2.15; Tacoma, $2.15; Seattle, $2.15; San Francisco, $1.70.

Metal Clips for Supporting Bars—$4.50 to $6.50 per 1,000, depending on size.

For the majority of the prices given we are indebted to the Universal Portland Cement Co., Sandusky Portland Cement Co., Concrete Steel Co., American Sand & Gravel Co., Chicago, and F. T. Crowe & Co., Seattle, Portland, Spokane and Tacoma.

Reinforcing bars for mill shipments are in general sold on a Pittsburgh basis; that is, at the Pittsburgh quotation plus the freight to the point in question, and with the following list of freight rates on finished material and the Pittsburgh quotation given, the price of bars at any of the points listed can be readily computed.

From Pittsburgh, carloads, per 100 lbs. to:

Albany	16.9 cts.
New York	16.9 "
Philadelphia	15.9 "
Baltimore	15.4 "
Boston	18.9 "
Buffalo	11.6 "
Cleveland	10.5 "
Birmingham	45 "
Cincinnati	15.8 "
Chicago	18.9 "
Denver	68.6 "
St. Louis	23.6 "
New Orleans	30 "
Minneapolis	32.9 "
Indianapolis	17.9 "
Kansas City	43.6 "
Omaha	43.6 "
Pacific Coast Points (Rail)	80 "

Now that the Panama Canal has been opened to traffic ocean freight rates on reinforcing bars to Pacific Coast points have been established which materially lower the delivered cost of bars from the east. The rates per 100 lbs. to Pacific Coast points for large lots are: From Pittsburgh, 61.9 cts.; Chicago, 76.5 cts.; Youngstown, 63.9 cts.; New York, 45 cts.; Bethlehem, 52.9 cts.

Concrete

Cement Age

Vol. 7 *Detroit, October, 1915* *No. 4*

Popularity of Stucco

THE value of concrete as a house building material possessing exceptional merit is beyond question. Numerous methods of employing concrete economically, both in units and in monolithic form, are available. No other material combines in so great measure permanence, fire-proofness, moderate cost and potential artistic merit.

The failure of concrete to come more fully into its own as a house building material has been due not to the material itself but to the lethargy and indifference of the great body of architects and builders to a wonderful material. The popularity of the stucco house indicates public recognition of the beauty of concrete and a reaching out for better construction.

Stucco—a Better Material

THIS number of CONCRETE devotes much space to presenting the best thought and practice in stucco work. It is believed that close attention to the experience of those who have contributed to the discussion in the *Information and Consultation* department will do much to improve the quality of this popular material.

There is no question that stucco properly applied to a wood frame is a long step in advance as compared with the wood covered house. It generally makes a good appearance, often in spite of crude design and indifferent workmanship. It requires far less up-keep than the wood building and is fire-resisting to a considerable degree.

Stucco on Concrete—The Logical House

THE great fault of stucco as now used is that it is not what it proclaims itself to be. It is an imitation, a makeshift. The designs of the vast majority of stucco houses express the feeling of masonry or more properly monolithic construction. Undoubtedly this apparent massiveness and appearance of permanence accounts in a large degree for the enthusiastic reception of this material by the public which realizes the flimsiness of the frame buildings which constitute our national fire peril.

Stucco is not a structural material, it is only a finish—the skin which clothes the structural body. The application of a skin purporting to be concrete to a frame of wood is illogical and, as experience often shows, disastrous. Stucco applied to clay tile and to brick is more true and logical, but in practice the fact that Portland cement and clay products have very different coefficients of expansion with changing condition of moisture and temperature has made this combination less desirable than it otherwise would be.

The logical application of stucco then is to the structural material it purports to be—concrete. For convenience the concrete base may consist of units such as block or tile or it may be applied to monolithic walls with entire success.

Concrete which is to receive stucco should not be too dense, at least at the surface. It should have a mechanically rough face and the quality of absorbing a certain amount of water which assists in curing the stucco as well as giving proper bond. The stucco skin itself will resist the action of the weather while dryness and even temperature are secured by proper air-spacing within the structural wall and by intelligent ventilation.

How's Business?

AN inquiry on business conditions, addressed to business men in 10 large business centers, was recently made by the editors of *System*, Chicago. Out of 163 replies, business was reported "good" by 60 executives, "exceptional" by 40, "fine" or "above normal" by 23, "fair" and "fairly good" by 18, "normal" by seven, "nearly normal" by three, "doubtful" and "Watchfully waiting" by four, "dull and poor" by seven and "much below normal and very poor" by one. This sounds encouraging. It would have been interesting to know what lines of business were covered in the replies, but on the face of it it looks as if we might all take a long breath and go forward, in the confidence that there is business. An optimist was asked: "How do you find business?" And the answer was: "By going out and looking for it."

Seventy-eight Vote for Concrete Silos

OWNERS of 13 silos in Saline Co., Mo., were asked: "If you were building another silo, what kind would you build?" Seven were undecided, six favored the wood stave, 76 favored monolithic concrete, one favored tile, one favored brick and two favored concrete staves. The figures are significant. Out of 87 owners who expressed a preference, 78 spoke for concrete silos. Only six were satisfied with wood—and it is probable that they had never tried concrete. The report is the more significant in that it comes from Missouri, where men have at least a reputation for being convinced only when a definite demonstration has been made.

In Wind, Flood and Fire

THIS has been a great year for concrete to establish its durability and permanence. Numerous fires have occurred where the material has shown its remarkable fire-resisting qualities and the protection it affords to life and property. On another page will be found an account of concrete's behavior in flood as shown by the record of the numerous concrete bridges in that section of the city of Erie which was visited by the destructive flood in July this year.

In Cincinnati, where a cyclone and severe windstorm did enormous damage in early July concrete again comes to the front. A local paper referring to the general destruction of property during the gale says that the sixteen-story Ingalls Building, built of reinforced concrete in 1902, emerged from the wind storm with but a few panes of glass broken. The Lippincott Building, at Second and Main Streets, though in the direct path of the storm, suffered no damage whatever in the structural portion. About fifty panes of glass were broken and the parapet wall, which extends 8 ft. above the roof, was blown over. On the other hand, buildings along side of this, constructed of other materials, suffered severely.

The Concrete Porch—a Plea for Its More Extended Use

CONCRETE as a better material for porch construction is making progress, but thousands of houses are still being built in which wood is used for this exposed portion of the building. The porch is usually the first part of a house to be replaced and particularly so since less durable woods have replaced pine.

Concrete is the logical material for porch and steps. It is permanent, it is inexpensive, it is clean and attractive. To use less permanent material except on the frame house seems inconsistent and on the frame house the concrete porch makes permanent this troublesome detail and cannot fail, as time passes, to educate the owners, tenants and other observers to the value of concrete as a house building material.

Concrete in the Power Plant

The following is an abstract from an address by Leonard C. Wason, C. E., Pres., Aberthaw Constr. Co., Boston, delivered before the Natl. Assn. of Cotton Mfrs.:

In the steam power plant, concrete can be used to very good advantage, not only in the building itself, but for boiler foundations. Especially where the ground is soft and of uneven bearing capacity, concrete is unexcelled, because a reinforced mat can be put over the whole area, so that the boilers are practically floated on their foundations. It is not advisable, however, to use concrete higher up for a boiler setting, although in isolated cases this has been done. Brick is better adapted to this purpose. Concrete is liable to shrink and open large cracks through the setting, which would permit the escape of gases. These cracks, being difficult to fill thoroughly and permanently, are objectionable.

Although concrete will withstand for an indefinite period a temperature of 500° F., a temperature of 800° F. or more will ultimately disintegrate it. It it thus not a proper material to be used in the fire-box, or where temperatures are high. The writer knows of special cases in which concrete, using crushed fire brick for coarse aggregate, and as sand the finer particles of fire brick, has been in use in furnace construction for several years without deterioration. He does not consider, however, that a few isolated examples of this are sufficient to prove its general adaptability for such purposes.

By the time the burning gases from a boiler reach the chimney, however, the temperature is such that no damage is likely to ensue, and chimneys can be easily and cheaply built of reinforced concrete. Instead of a heavy gravity construction as is used with brick, the design is that of a broad base and vertical shaft, tied rigidly together so as to be a unit. Thus the chimney might be compared to a candle, which by itself is unstable, but when set in a candlestick the combination cannot be readily tipped over.

Chimneys are built with various details of design, all of which have proved stable and durable. For ease of construction, the shaft is made of a uniform diameter from bottom to top, which gives the chimney a somewhat top-heavy appearance as compared to the tapering brick chimneys with which we are so familiar, and to which our eye is educated. This type of chimney can be built more quickly than one of brick, and can be put into service as quickly after its completion. The reason so many are built of concrete is their low first cost. Some concrete chimneys have failed, due to the use of dry concrete. Those made with wet concrete have proved satisfactory.

How Wet a Mixture

Just what is the proper consistency? The tendency has been toward wetter mixtures of late. The most recent developments along this line are reported by the Testing Laboratory of Cornell University. Experiments were made with 1:2:4 mixtures and varying percentages of water.

It was found that 27½% water developed a concrete that showed the maximum resistance in tension and compression tests at the end of 30 das., and that to obtain the same strength in wetter mixtures an increase of at least 5% in material was necessary. This can be saved by carefully observing the 27½%. "Point of Diminishing Returns." —*Knickerbocker Komments.*

Concrete-Cement Age

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC.

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Roy Marshall, 27 La Salle Gardens, North, Detroit.
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There are no bonds, mortgages or other securities issued.

(Signed)

Walter C. Boynton,
General Manager.

Sworn to and subscribed before me, a Notary Public in and for the County of Wayne, State of Michigan, this twenty-eighth day of September, A. D. 1915.

IONE MICHAEL,
Notary Public.

(My commission expires Mar. 19, 1919.)

Features in the Construction of New Building for the *Youth's Companion*, Boston

By W. B. Conant[1]

A new concrete slab construction, known as the Smulski or S-M-I system[2] and said to save about 30% of the steel, is employed in the building of a new plant at Boston, Mass., for the Perry Mason Co., publishers of *The Youth's Companion.* The building is designed to house the mechanical, editorial and business departments, and because of the very large printing presses and other machinery to be installed, exceptionally heavy loadings were provided for, particularly at the second floor.

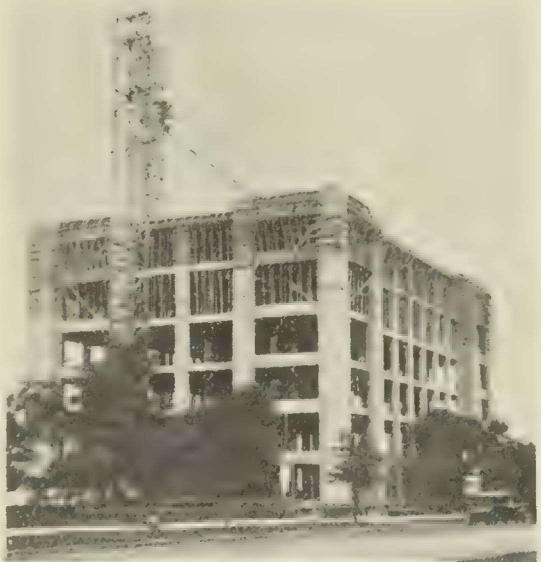

Fig. 1—General View of Perry Mason Pub. Co. Building, Boston

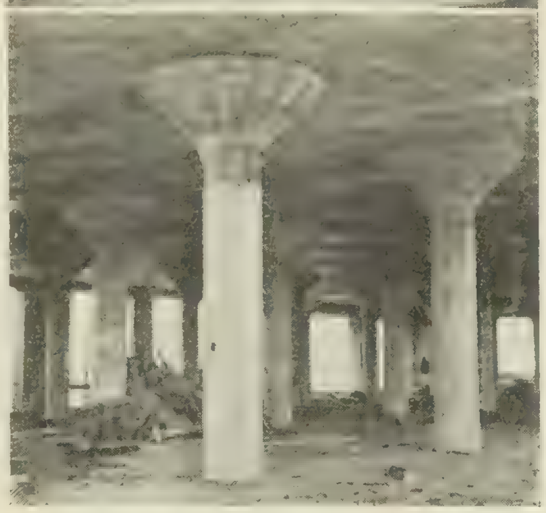

Fig. 2—General View of Concrete Columns and Floors After Stripping Forms

GENERAL FEATURES

The building is of reinforced concrete throughout, with a small amount of brick facing, and is provided with all-steel sash[3], which occupy the entire sides except for the wall columns, and low curtain walls below the windows. The location is on Commonwealth Ave., Allston district, about 3 mi. from the center of Boston, the ground being of fine sand, with a considerable slope to the street.

All columns have independent footings. The inside footings were 8′ 6″ x 8′ 6″, 3′ deep, and reinforced with two layers of steel, each of which consisted of 17 ¾-in. round bars. The wall footings were 8′ x 6′, reinforced with 27 ⅝-in. round bars in the shorter, and 19 ⅝-in. round bars in the longer direction. The corner pieces have footings of special shape.

The building is six stories above the basement, 165′ front by 100′ deep, and each floor is divided into bays 20′ 6″ x 14′ 9″, the long way of the bay being lateral of the building. The story heights are: basement, 11′ 9″; first floor, 14′; second, 13′; third, 12′; fourth, 13′; fifth, 14′; sixth, 12′ 8″.

Outside walls, amounting merely to columns, have 5-ft. 2-in. x 4-ft. 10-in. faces at corners and are 2′ 10″ thick; typical intervening columns are 3′ 6″ wide and 1′ 7″ thick. Typical spandrel beams are 1′ 3″ x 1′ 8″ in section, above which are curtain walls, 2′ 10″, 3′ 8″ or 6′ 5″ high, according to floor, increasing upwards. Inside columns are round, with 6-ft. mushroom heads; the columns in the basement are 26″ in diam. and on the floors above, 22″ in diam.

Structural slabs are of three general types: 1, a 9-in. slab, for the second floor, designed and constructed for a live loading of 300 lbs. to the sq. ft.; type 2, an 8-in. slab, for basement over sub-basement, first, third, and fourth floors, 200 lbs. live load; type 3, a 7-in. slab, floors five and six, for 100 lbs. live load per sq. ft. The second floor construction is extra heavy for the reason that it will carry the cylinder presses. The roof slab is 7″ thick.

MATERIALS

Giant cement,[4] Plum Island sand and gravel, in varying proportions of 1:1:2 and 1:2:4, were selected as concrete materials. The stone was ¼″ to 1¼″, and was brought from the dock by team and dumped from a plank platform at roadway level to a pile on the ground about 8′ below, which was the level of the construction yard; sand, also brought by team, was deposited in a long pile in front of the cement shed, which was about 125′ x 30′ and constructed of 1-in. boards and provided with a tar-paper roof.

CONSTRUCTION EQUIPMENT

Three wooden towers were used on the job, one 175′ high, with elevator and hopper, erected adjacent to the back wall of the building at its center line; two auxiliary towers, 150′ high, which were connected by wire cable, were erected, one at either end of the building at its wall center line. To the cable was attached the rigging, from which the 3-joint metal chute was suspended. Fig. 1 shows the arrangement of the towers.

The ⅓-yd. Ransome steam-operated mixer[5] was located at ground level at the base of the 175-ft. tower. Materials were conveyed by barrows operated on plank runs from the aggregate piles and the cement shed, and dumped into the mixer elevator, which raised them to a height of about 10′ and automatically discharged them into the mixer, to which water, obtained from a pipe connected with the city main, was emptied from a tilting box which indicated the amount required for a batch.

FORM WORK

Foundations, beams and walls were poured in wooden forms, and the floor slabs and inside columns with the use of sheet iron forms[6] of about No. 18 ga. The floor forms were laid on a falsework of joists sup-

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[1] Concord, Mass.

[2] Edward Smulski, Boston

[3] Trussed Concrete Steel Co., Youngstown, Ohio

[4] Giant Portland Cement Co., Philadelphia

[5] Ransome Concrete Machy. Co., Dunellen, N. J.

[6] Deslauriers Column Mold Co., St. Paul, Minn.

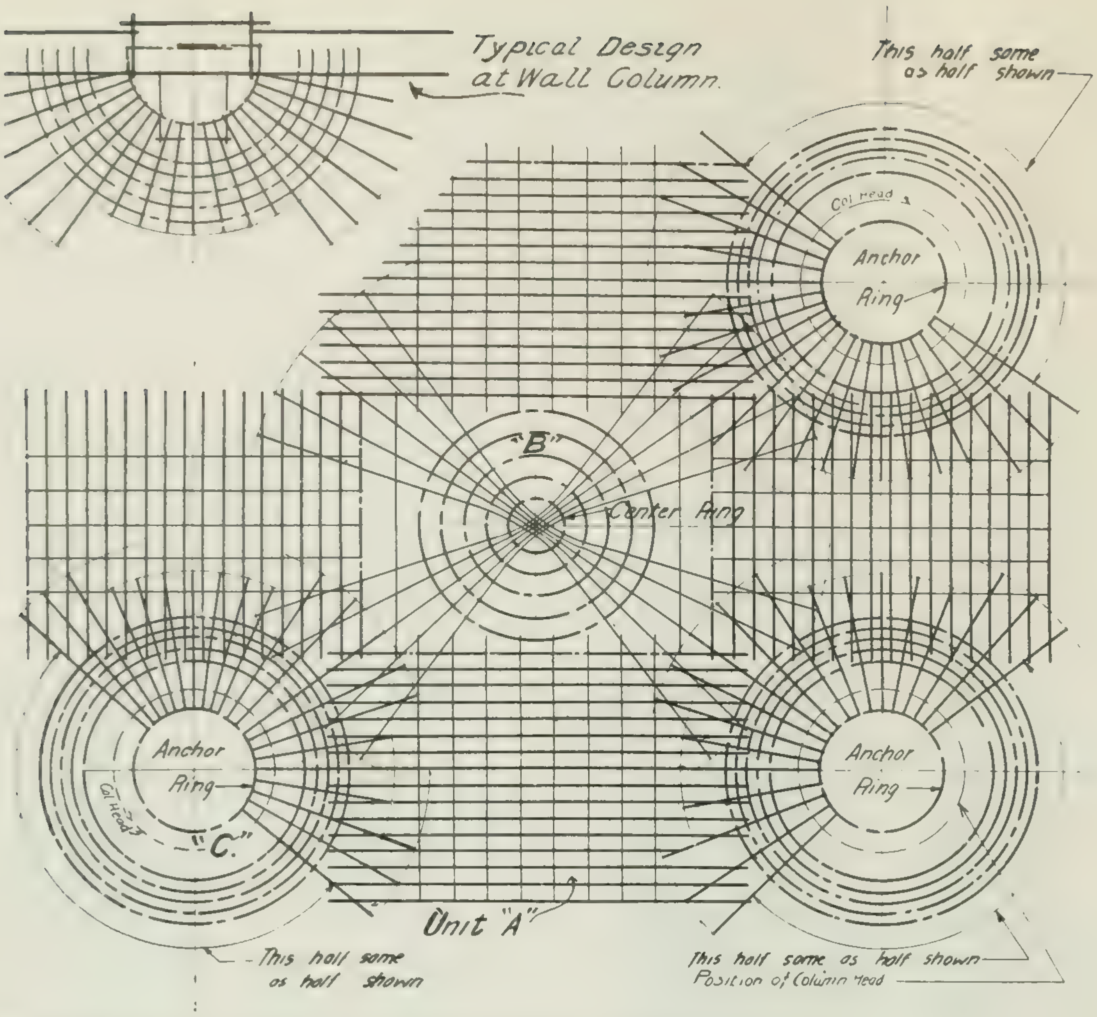
Typical Design at Wall Column
This half same as half shown
Col Head
Anchor Ring
"B"
Center Ring
Anchor Ring
Col Head
"C"
Unit "A"
Anchor Ring
This half same as half shown
This half same as half shown
Position of Column Head

Fig. 3 Diagram Showing Arrangement of Reinforcing

ported on shores, and united with the sections of circular column forms, the mushroom heads coming to the level of the floor, for pouring at the same time.

COLUMN AND WALL REINFORCING

The total amount of steel used in the building was, in round numbers, 350 tons. Outer wall columns were reinforced with 1-in. vertical bars and smaller, 10 bars to 22 bars to the column, and with $\frac{3}{8}$-in. horizontal hoops, 12″ o. c. Inner circular columns were reinforced with 1″ x 1″ vertical bars, for floors from basement to second floor, inclusive; $\frac{7}{8}$-in. deformed round rods for floors three and four, and $\frac{3}{4}$-in. round bars for floors five and six. Columns of the basement, first, second and third floors were further reinforced by $\frac{3}{8}$-in. deformed rods forming spirals having a pitch of $1\frac{3}{4}$″ in the basement columns and a 2-in. pitch for the three floors above; while the columns of floors four and six had $\frac{3}{8}$-in. round deformed hoopings at 12-in. centers. Spandrels were reinforced with $\frac{3}{4}$-in. and $\frac{5}{8}$-in. horizontal bars, $\frac{3}{4}$-in. truss rods for shorter spans lengthwise of the building, $\frac{7}{8}$-in. horizontal and $\frac{7}{8}$-in. truss rods for larger spans, and $\frac{1}{2}$-in. stirrups 10″ o. c.

FLOOR SLAB REINFORCEMENT

The reinforcement for floor slabs consists of three kinds of separate units marked A, B and C. Units A consisted of straight bars and were placed between columns. Units B were placed in the center of the slab, and units C at the column head. (See Figs. 3, 4 and 5.) Each panel reinforcement therefore, consisted of one unit C, one unit B, and two units A and the secondary reinforcement across Bands A described below. Units A and B were near the bottom of the slab, and units C near the top of the slab. The composition of the units varied for different loadings, as given below. Certain features of the design are patented.

Units A.—Units A, placed lengthwise of the building, were short, the length of bars being 8′. They consisted of 20, 18 and 17 bars, placed 7″, 8″ and $8\frac{1}{2}$″ o. c., according to the live load. The units placed across the building were 13′ in length

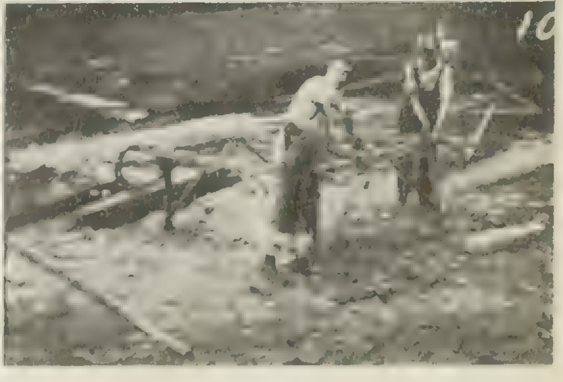

Fig. 5—Typical "Unit C"
Fig. 7—Typical "Unit B"
Fig. 9 Typical Wall Unit
Fig. 6—Fabricating "Unit C"
Fig. 8—Pouring Concrete
Fig. 10—Assembling and Wiring "Unit A"

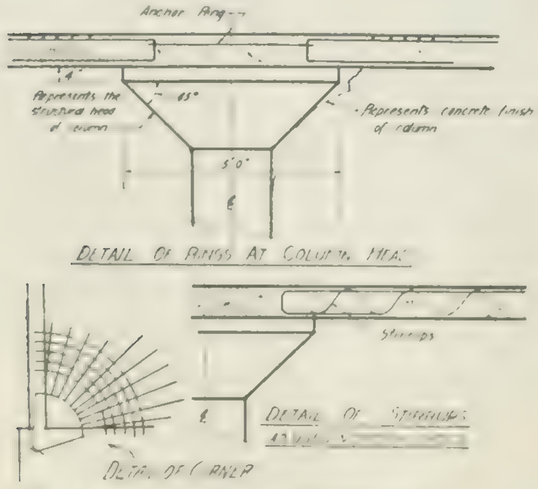
Anchor Ring
Represents the Stirrup head of column
45°
Represents concrete finish of column
5'0"
Detail of Rings at Column Head
Stirrups
Detail of Stirrups
Detail of Corner

Fig. 4 Details of Reinforcing

and consisted, according to loading, of:

For interior panels, 15 ½-in. round bars; 13 ½-in. round bars; and 10 ½-in. round bars.

For exterior panels, 12 ⅝-in. round bars; 10 ⅝-in. round bars; and 12 ½-in. round bars. (See Fig. 4.)

Units B—These units were composed of five concentric rings with a minimum diameter of 2′ 4″ and a maximum diameter of 7′, and two sets of five bars each, placed diagonally across the panel. These bars were 17′ 6″ long for interior panels, and 19′ 6″ long for exterior panels. (See Figs. 3 and 7.) They were slightly curved so as to converge toward the center and spread out at the ends.

Units C—These units were the most rigid and consisted of radial bars, 36 to 40 in number, and rings. The radial bars were bent in a U shape with unequal prongs. When placed in position the longer prong near the upper face of the slab resisted tension, while the shorter shorter prong near the lower surface resisted compression. The diameter of the radial bars varied from ⅝″ to ½″, and the length of longer prong from 5′ 0″ to 3′ 6″, according to their position and loading.

The radial bars engaged at their inner ends a 1-in. center ring 3′ 8″ in diameter located directly over the center of the column head and entirely within the enlarged column head. On top of the radial bars were placed five concentric rings, with a minimum diameter of 6′ 8″ and a maximum diameter of 9′ 4″. The diameter of the bars used for the rings was as follows:

For 300-lb. load, the smallest ring was ⅞-in. round, and the remaining four ¾-in. round bars.

For 200-lb. load, the two inner rings ⅝-in., and the other rings ¾-in. round bars.

For 100-lbs. load, the inside ring was ¾-in., the next two ⅝-in., and the two outside rings ½-in. round bars.

To keep the units C a proper distance above the forms, the ends of the rings at the splice were provided with hooks of proper length. The splices of the rings were distributed around the circumference of the unit so that finally the unit was supported on 10 points around the circumference.

Wall Units C—Wall column units consisted of radial bars of the same shape described above, engaging a half center ring and five concentric half-rings of the same diameters as the rings for the interior column heads. The half center ring was well anchored into the column. The half-rings were extended into the spandrel beam and anchored by means of hooks. The construction of the corner rings was on the same principle.

Secondary Reinforcement — Besides the main reinforcement, secondary reinforcement was placed at right angles across bands A. These bars were ⅜″ in diam. 10′ long, for the lateral lines, and 8′ long for the longitudinal lines, all 12″ o. c.

Erection of Units—Units A and B were assembled to a template and wired in the yard. After being completed, the units were stored in the yard and then when required placed on the construction. The templates can be seen in Figs. 6 and 10. The position of the rods on the template was fixed by nails and plugs driven in proper locations so that the assembling of the units consisted merely in placing the bars in properly marked places. This made the assembling very easy and obviated any possibility of error. The straight bars in units A were wired to two cross-bars placed one at each end. After the form work was completed, the units were hoisted by means of a derrick, two units C at a time, as can be seen in Fig. 11. The placing of the units was very rapid.

Concrete Floors—As can be seen in Fig. 3, the space within the centering ring of Units C has no reinforcement. The unit, therefore, does not interfere with the column reinforcement and the concrete can be poured very easly through this opening.

Theoretical Consideration — The main aim in this system of reinforcement was to place the reinforcement in the direction of the stresses so as to make the reinforcement most effective. At the column head the stresses act radially and circumferentially. In units C, therefore, the steel is placed in radial and circumferential directions. The purpose of the rings is not only to resist circumferential stresses but also by their hooping effect to prevent the concrete from spreading under load and cracks from developing. Therefore, the rings resist both circumferential and radial stresses.

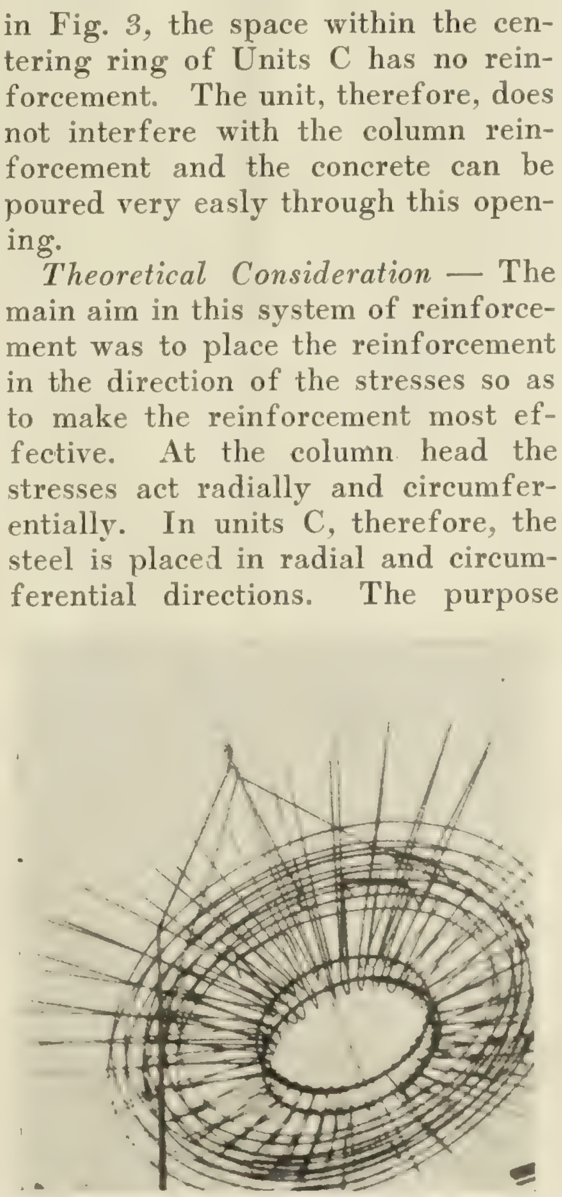
FIG. 11—HOISTING UNITS C

The bending moment around the column head is variable, being maximum in the diagonal direction and minimum in the short span. By proper arrangement of the radial bars, it was possible to make the amount of steel proportional to the bending moment and span. This resulted in great economy.

Slick deformed round bars[7] were used in all the floors except the sub-basement and part of the basement slab, which were placed directly on the ground, and in which triangular wire mesh No. 42 was used. All steel was bent at the contractor's shops in Cambridgeport, about 2 mi. distant, and hauled by wagon to the site.

CONCRETING

Concrete was mixed 1:2:4 for the slabs and walls, 1:1:2 for columns up to and including the second floor and 1:2:4 for columns above the second floor.

Concrete was sluiced and shoveled into place at it came from the chute through a readily moved wooden trough resting on wooden horses. (Fig. 8). A man on a platform at the hopper directing the elevating and flow of the concrete. The slab surface was screened, and after concreting was completed, a 1-in. granolithic surface was applied to each floor, and walls and columns were given a neat finish coat.

CONSTRUCTION DATA

Field work was undertaken Apr. 1, 1915, when the survey was begun and the field office started. The contractors began concreting Apr. 15, and Aug. 15 all the floors had been poured. An average of 50 men were employed on concreting and about 50 carpenters continuously worked on form work. Four plumbers were occupied with pipe work as construction proceeded.

PERSONNEL

The architects and engineers in charge of construction are Densmore & LeClear, Boston, the direct supervision being under the charge of Albert A. Densmore. The process of reinforcement was designed by Edward Smulski, who is associated with Sanford E. Thompson, Boston, the consulting engineer. The contractor is The W. F. Kearns Co., Cambridgeport, Mass.

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[7] Cambria Steel Co., Johnstown, Pa.

Patents on Sand Molds in Concrete Stone Manufacture

There is a wide-awake interest at this time in the use of sand molds in casting concrete. Numerous patents have been granted covering the use of sand molds and these have been so far sustained in the courts as to limit the use of the process—with few exceptions—to the few who have paid for the right to manufacture under the patents.

This magazine has already published a great deal on the subject of sand-cast stone manufacture,[1] so the methods in use by leading manufacturers are of public record. Inasmuch, however, as one early patent has already passed its 17-yr. period of life and another patent is soon to expire, it seems important, particularly in view of the many inquiries which have been received by this magazine, to publish at least a summary of the patents which have been issued and the names of those controlling them.[2] The summary follows:

Aug. 4, 1891, Charles W. Stevens, Lansing, Mich., was granted a patent (No. 457,231) covering a process in artificial stone manufacture, the purpose of which was "to simulate perfectly the appearance of rough hewn blocks of natural stone." The essential feature of the patent, so far as practice goes, is described in the patent paper as follows:

> In practicing my invention I prepare a box of any suitable dimensions for forming the outside lines of the brick. Those being in use intended to be covered up may be made in the usual manner. It is in forming the face of the brick in imitation of cut stone that my invention lies. To do this I prepare in the bottom of the box a mass of ground stone or sharp sand, which usually resembles in appearance the disintegrated particles of stone which I propose to imitate. I preferably shape this mass by hand or by any other suitable means into irregular surfaces, and into the mold upon the top of the sand so prepared, I pour plastic material of any ordinary kind usually employed in the manufacture of artificial stone, such material usually consisting of sand or ground stone, with cement and water, or the like to give it the proper consistency and bind the parts together in a homogeneous mass. When the plastic material is poured into the mold, a portion of the cement sinks into the sand, prepared as described, binds it together and assimilates it with the material poured into the mold.

This method of producing "rockface" has been almost forgotten by the industry and memory of it would not be revived here, except in order to make as complete a summary as possible of the history of the development of the use of sand in molding concrete.

June 1, 1897, Charles W. Stevens, Lansing, Mich., was granted a patent (No. 583,515) relating to the manufacture of artificial stone intended for use chiefly in ornamental work and involving the use of sand in forming not only the face of the material but a core in producing hollow trim work. This patent describes the use of a dry mixture of cement and fine aggregate placed in this sand mold and backed up with a sand core. Hydration was obtained subsequent to placing the materials by saturating the surrounding sand with water. After the hardening, the sand forming the mold and the core was removed.

May 9, 1899, Charles W. Stevens, Harvey, Ill., was granted a patent (No. 624,563) relating to an improved process for the manufacture of artificial stone. This is particularly an improvement on the method described in patent No. 583,515, and the improvement lies particularly in the use of a wet mixture rather than dry mixture of cement and aggregate deposited in the sand mold. This appears to be the first patent on sand cast concrete stone, as this method of manufacture is now understood. One of the important features of the process is in providing for a mold which will absorb the surplus moisture from the concrete mixture in order to give a dense material. This patent also covers the use of a relatively dry facing mixture in the sand mold with a wet mixture poured in behind it, the dry facing absorbing the necessary moisture from the wet backing. This latter idea in manufacture is not in common use.

May 6, 1902, Charles W. Stevens, North Harvey, Ill., was granted a patent (No. 699,587). This patent relates to improvements in the manufacture of artificial building stone and is especially intended for use in the construction of outer walls for buildings. The idea was to obtain units which would give an air space, practically continuous. These units, with three walls, were to be made by the method described in patent No. 624,563, and when laid up in the wall the space between the center web and the outer web was to be filled with a wet mixture of concrete. No mortar was to be used in laying up the units. The webs were connected by ties of pre-cast concrete posts or other materials.

May 6, 1902, Charles W. Stevens, North Harvey, Ill., was granted a patent (No. 699,588). This relates to improvements in the process of making artificial stone, employing as a mold either dry sand, earth or similar material to absorb the moisture from the concrete mixture. This improvement relates merely to the method of adapting sand molds to form hollow building units having either one hollow space or several, separated by interior webs or walls.

July 22, 1902, Charles W. Stevens, North Harvey, Ill., was granted another patent (No. 705,156) covering the manufacture of a veneer facing to be made in sand molds with bolts having lugs cast into the back of the units, these to be held, as laid up in a wall, by a wet mixture of concrete which was to be poured between the facing units and the frame, or inner wall of the building.

Oct. 14, 1902, Jacob C. McClenahan, Coldwater, Mich., was granted a patent (No. 711,436) involving essentially the basic idea of sand molds, but using either natural sand or stone dust or a similar porous material saturated with a chemical solution consisting of sulphuric acid, alum and limewater. It is explained in this patent paper that the object in saturating the sand or stone dust mold with the chemical solution is to supply a material which will harden and seal the surface of the stone to be cast in the mold.

Nov. 3, 1903, Charles W. Stevens, Harvey, Ill., was granted another patent (No. 742,924) involving an improvement in the manufacture of artificial stone, the purpose of which, like the patent granted to Mr. McClenahan, was to harden the surface of the stone and render it impervious to water. The patent is written to cover the use of any material used in the way described by Mr. Stevens in getting this hardening effect, but it particularly recommends the use of a mixture of limewater and saccharine matter and in actual practice, consists in the mixture of 1 lb. sugar to 2½ gal. water. This hardening solution of limewater and sugar was to be mixed with sand, and this mixture constitutes a coating which is spread over the face of the pattern. This material is then backed up with sand, the mold box is reversed and the pattern is removed. The concrete is then cast in the sand mold, the facing of the mold being covered with the hardening compound. This hardening compound is to be put on in a thin layer only, so that the excess moisture in the wet cast concrete would be absorbed through it into the comparatively dry sand of the mold beneath.

Aug. 22, 1905, Walter P. Butler, Minneapolis, Minn., was granted a patent (No. 797,553) relating to an improvement in the process of the manufacture of either hollow or solid artificial building block, using a mixture of cement and aggregate cast in a mold made wholly or in part of a molding compound of sand, crushed stone or any similar granular material, mixed with a proper proportion of powdered talc or powdered soapstone, or any other similar material having smooth, soapy, slippery properties. The object of this compound is to produce not only a finer grained mold intended to give sharper and more cleanly cut lines, but also to decrease the absorptive properties of the material forming the mold over what is possible with the use of sand or crushed stone only. It was Mr. Butler's claim that by minimizing the amount of this absorption in the concrete mixture, the hardening is accelerated and a more dense material made possible. Mr. Butler also advanced this process as doing away with the necessity for the use of a hardening solution or compound in the molding material itself, as in other patents previously granted.

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[1] Some of the more important articles published in this magazine are as follows: "Concrete Stone Tooled by Machinery," Feb., 1913, p. 61; "Concrete Products—Architectural Considerations," Oct., 1913, p. 155; "The Use of Sand-Cast Concrete Veneer Slabs in Louisville Residence," Apr., 1914, p. 177; "Producing a Concrete Stone That Will Not Craze," Sept., 1914, p. 123; "Synthetic Stone is Used in the Construction of Catskill Aqueduct Buildings," Mar., 1915, p. 125; "The New Delaware and Hudson Office Building, at Albany, N. Y." (includes description of methods used in sand-cast stone manufacture), June, 1915, p. 289

[2] Patent papers may be obtained from the U. S. Patent Office, Washington, D. C., for 5 cts. each (in coin or money order); ask for them by number, name and date

Design Methods in Concrete Construction—Arches with Fixed Ends

By A. M. Wolf, C. E.

This is the seventh of a series of articles on Design Methods in Concrete Construction, the first having been published in the Jan., 1915, issue. The present article on the design of Concrete Arches with Fixed Ends, by A. M. Wolf, C. E., is in two parts, of which the following is the first.

The popularity of concrete for bridge construction lies in the fact that structures of this kind have greater durability, require little or no maintenance, are subject to little or no vibration and can be more readily molded in pleasing and harmonious forms than any type of steel bridge.

Concrete is pre-eminently suited for arch construction since it is strongest in compression and in arches the principal stresses are compressive. In most of the early construction, therefore, little or no reinforcement was used in the arch rings since they were proportioned in the same manner as masonry arches, that is, so as to be in compression at all points.

After a time, steel reinforcement in amounts equal to ½% to 1¼% was added in arch rings designed in this manner, not to enable cutting down the thickness of the arch ring, but with the idea in mind that added strength could be obtained at a small additional cost and at the same time steel would act as a safeguard against cracks due to slight settlement of foundations, undue temperature stresses and shrinkage of concrete in hardening. In so far as efficient employment of reinforcement is concerned, the Melan type no doubt stands first, the structural steel rib reinforcement being used to support entirely or in part the forms and concrete during construction, and thereby is stressed considerably before the concrete takes any load whatever. For the reason stated above the cost of centering is also reduced in this type.

DEFINITION OF TERMS

The technical terms used for various portions of masonry arches are used in the most part for the corresponding portions of concrete arches, even though the construction is different and it is therefore deemed wise to include at this point a glossary of these terms. Referring to Fig. 1, the span is the horizontal distance between abubtments or piers which support the arch ring, the abutments being the end supports and the piers the intermediate. The under or concave surface is called the soffit and the upper or convex surface, the back. The springing line is the line at which the soffit merges with or intersects the face of abutment or pier. The rise is the vertical distance from springing line to highest point of the soffit. The crown is the highest point of the arch ring. The inclined surface at right angles to arch ring which extends back from the springing line and upon which the arch ring rests is called the skewback. The axis is an imaginary horizontal line parallel to abutments passing through the middle point of a line joining the springing lines. The portion of arch between soffit and back and the skewbacks is called the arch ring. The intersection of the soffit with a vertical plane perpendicular to the axis is called the intrados and the intersection of the back with a similar plane is known as the extrados. The haunch is the portion of the arch ring between the springing line and the crown. The spandrel is the space between the extrados and the roadway; this may be filled with earth retained by walls parallel with the face of the arch, or spandrel arches or decking built up from arch ring to carry the roadway. The term voussoir really refers to stone masonry arches and is the name given the wedge-shaped blocks of stone composing the arch ring; the term is used a great deal, however, in referring to transverse sections of a concrete arch marked by construction joints or to the parts into which the ring is divided to facilitate design, as will later be discussed. The voussoir at the crown is known as the keystone. In large concrete arches the voussoir sections are sometimes cast with small spaces between which are concreted up after all voussoirs have hardened. These spaces are known as keyways or keys.

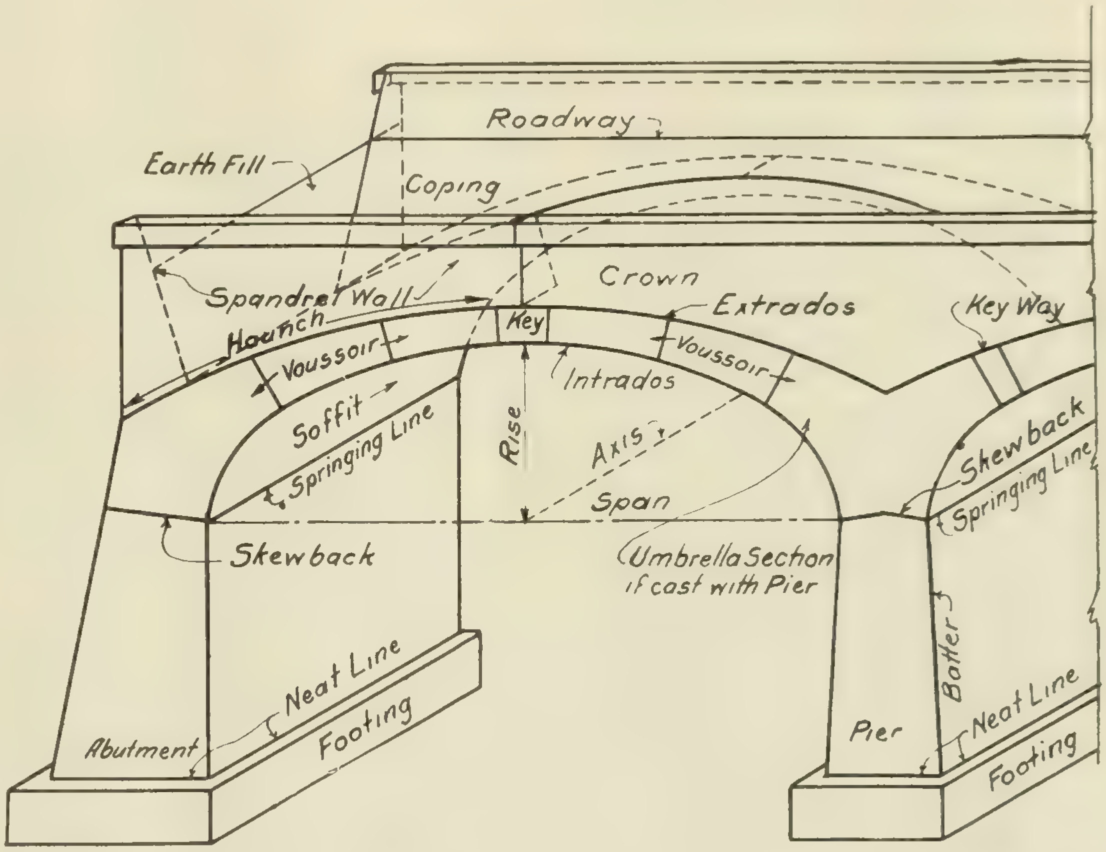


Fig. 1—Typical Concrete Arch, With Principal Parts and Technical Terms Indicated

CLASSIFICATION OF ARCHES

In this discussion only the concrete arch with fixed ends will be treated, but it may be well at least to define the other kinds of arches classified as regards type of construction and not shape of arch ring which will be discussed later.

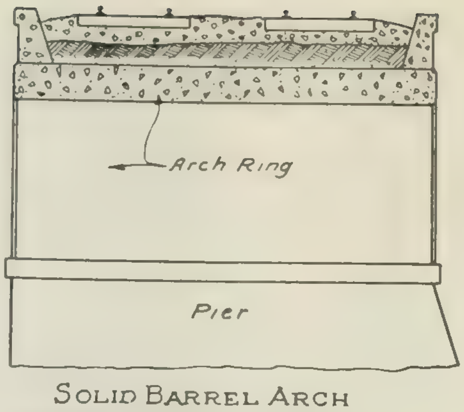
(a) As to Condition of Support.—Classified broadly as to condition of end supports there are (1) hingeless or fixed arches and (2) hinged arches, the end connections being made with abutments or piers by either metal or masonry hinges, with a similar hinge between sections at the crown; this is commonly known

as the three-hinged arch. This type has been used to a considerable extent in Europe, but very little in America. The advantages of the three-hinged arch over the fixed are: (a) Settlement of supports, within reasonable limits, does not injure the arch; (b) Temperature stresses amount to very little; (c) The arch is statically determinate, while the fixed arch is statically indeterminate; (d) Higher unit stresses can be used on account of advantages (b) and (c).

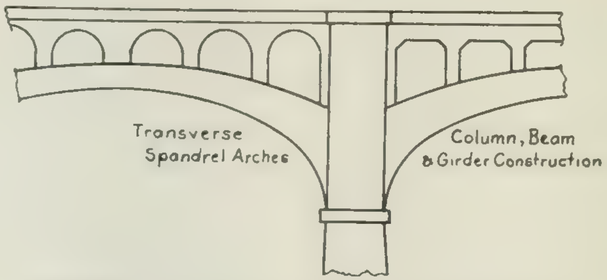
Two-hinged arches, with hinges at supports only, are used only in special cases as for through arches or those in which the roadway is suspended from the arch ribs, for they do not possess the advantages over the fixed arch mentioned for the three-hinged arch.

Occasionally the one-hinged (at crown) arch may be used to advantage if limitations in the total height of structure necessitate that the depth at the crown be a minimum, while the ring may be greatly increased in stiffness at the ends.

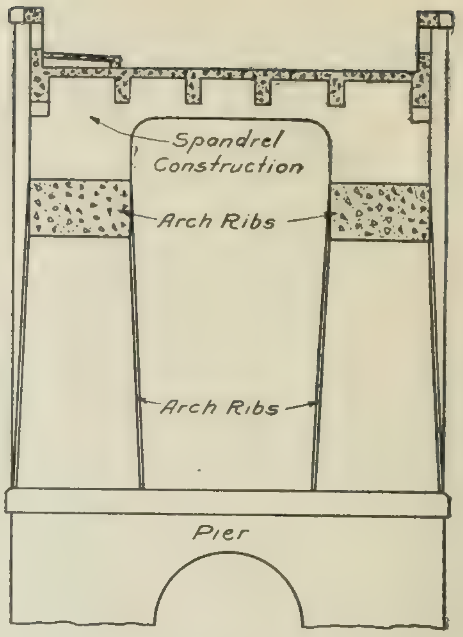
(b) As Regards Construction of Arch Ring.—Classified as width of arch ring or parts compared with width equal (or nearly so) to that of total width of bridge, we have (1) the solid barrel arch with the arch of piers or abutments and (2) the ribbed arch made up of two or three ribs spaced some distance apart. This last type, adaptable to open spandrel bridges, effects a large saving in dead load to be carried and is therefore almost exclusively used for long span arches. The two types are shown in Fig. 2.



Solid Barrel Arch
Earth-Filled Spandrel



Elevation Open Spandrel Construction
Of Two Types.



Ribbed Arch
Open Spandrel Construction

Fig. 2—Types of Arch Construction

Arches of the solid barrel type may be further subdivided into classes as regards spandrel construction, as follows: (a) The earth fill spandrel arch and (b) the open spandrel arch in which the roadway is carried on a deck composed of transverse or longitudinal spandrel arches or of slabs and girders on columns, as shown in Fig. 2. For arches of the ribbed type only open spandrel construction is used.

(c) As Regards Reinforcement.—Concrete arches can be grouped into two main classes (1) plain concrete and (2) reinforced concrete arches. The latter type may be subdivided into three groups as regards the arrangement of the reinforcement commonly known as: (1) The Monier type, the reinforcement consisting of longitudinal bars placed near intrados and extrados to take tensile stresses and aid the concrete in compression, with transverse distributing bars at right angles to the longitudinal and sometimes stirrups to tie the two sets of longitudinal bars together. This type is used a great deal both in this country and in Europe.

(b) The Melan type, the reinforcement consisting of a number of self-supporting structural steel ribs either I-beams or built-up latticed girder frames with angle flanges bent to the arch curve. In the ordinary reinforced concrete arch the full strength of the steel can never be utilized since the maximum compression in the steel cannot exceed 15 times that of concrete (ratio of moduli of elasticity). By the use of the Melan system wherein the arch forms are hung from the reinforcing ribs, a portion of the dead weight of the structure is transferred direct to the steel, so that the steel receives a certain initial stress before the concrete is stressed at all.

(b) The Wünsch type, practically unknown, except in Europe, consisting of an arch with horizontal extrados with a series of steel ribs near extrados and intrados connected at abutments by vertical members embedded in the concrete.

(d) The Luten type, a modification of the Monier type, used extensively in the U. S. In this type a single series of longitudinal reinforcing bars is used, so bent as to follow the intradosal curve for some distance either side of crown then bending up at the third, half and two-thirds points, into the extradosal plane and carried well back into abutments. (This type is patented[2]).

SELECTION OF ARCH CURVES

The most economical curve for an arch ring for any given system of loads is that of the linear arch, a curve which is in equilibrium under the action of a given loading, and which is an equilibrium polygon with an infinite number of sides. There are various shapes of linear arches each corresponding to the particular kind of loading which it holds in equilibrium. Thus, for a water loading on an arch the circle is the linear arch and therefore the most economical type, where the head of water is large as compared with the span.

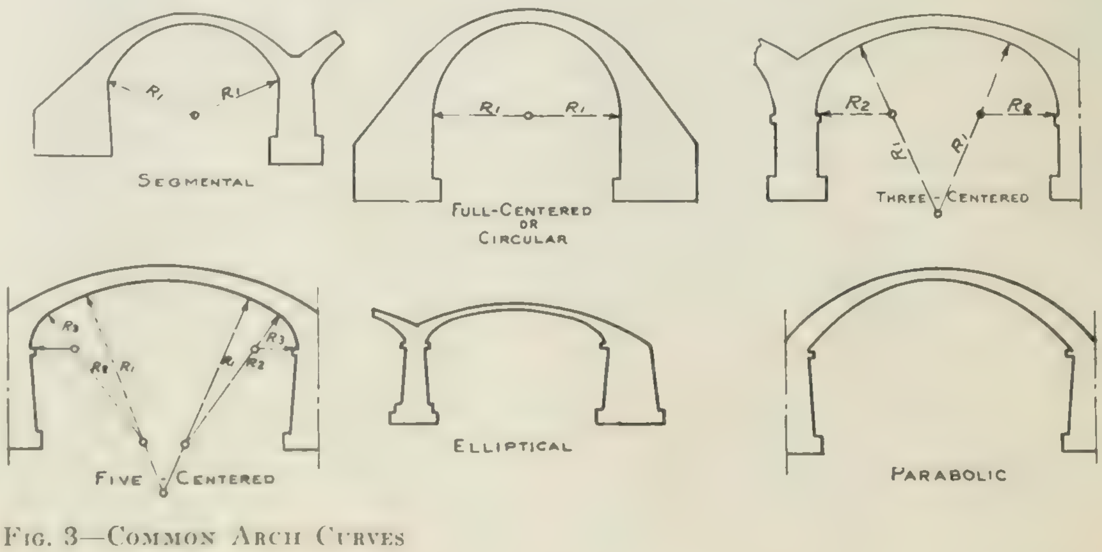


Fig. 3—Common Arch Curves

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[2] Daniel B. Luten, Indianapolis

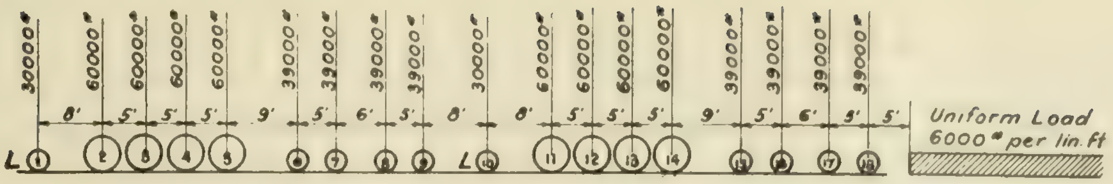

Fig. 4—Axle Loads for Cooper's E-60 Loading, Two 213-Ton Engines With a Uniform Following Load of 6,000 Lbs. Per Ft. of Track

For a uniform load on the horizontal projection, as where transverse spandrel arches are used and spaced at intervals not exceeding 1/7 of the span, the parabola is the proper curve to use. For an earth-filled arch with a rise less than 1/4 of span the transformed catenary is the best curve, while for arches of this type with greater rise the ellipse should be used.

In an actual arch the resultant pressure line found for a given loading is the linear arch for that loading. (See Fig. 7). Since the transformed catenary is unsightly and difficult to lay out, an approximate catenary is generally used by making up a compound curve of circles of different radii, commonly known as three-centered, five-centered or many-centered curves, depending upon the number of circles combined to make up the curve. For a given span and height of crown the maximum waterway will be obtained by using an elliptical arch.

Where the appearance of an arch is one of the main considerations the semi-circular arch ranks first, then the segmental, the parbola with circular curves at ends and finally the basket-handle or compound curve arch. In the construction of concrete arches the forms and centers may be erected just as readily for one arch curve as another and the use of the economical curves is therefore encouraged. This is not true of the stone masonry arch, the cost of which increases very rapidly for curves other than the semi-circular on account of the difficulty of stone-cutting.

ECONOMICAL TYPES FOR VARIOUS CONDITIONS

For arches with spans under 100′ the earth-fill spandrel bridge is the most economical; where the span is over 100′ and the rise high, the open spandrel construction of transverse arches, or columns supporting deck beams, should be used. The latter type of spandrel will in general be the cheaper but if the appearance is a main consideration the arched spandrel gives the better effect. For long-span arches the double-arch rib construction with open spandrels will be found the most economical on account of the lessening of dead weight.

THE DOUGLAS FORMULAS (1) (*Am Civil Engr's. Pocket Book.*)

Thickness in feet given by the following

Span in feet

Kind	Under 20*	20 to 50*	50 to 150†	Over 150‡
Plain Conc.	$0,04(6+l)$	$0.020(30+l)$	$0.00014(11000+l^2)$	$0.020(75+l)$
Reinf. Conc.	$0.03(6+l)$	$0.015(30+l)$	$0.00010(11000+l^2)$	$0.016(75+l)$

*For Culverts under a high fill, add 60%, for railroad arches, add 25% † R.R. arches, add 20% ‡ For RR arches add 15% In the above l = Span of Arch

THE FRYE FORMULAS (2) (*Civil Engr's Pocket Book.*)

Thickness at Crown tc in feet

For Highway Bridges $tc = \sqrt{0.01\,l\,(\frac{l}{h}+3)} + 0.15$

For high H.W. Embankments or R.R. Bridges $tc = \sqrt{0.01\,l\,(\frac{l}{h}+4)} + 0.20$

For high R.R. Bridges $tc = \sqrt{0.01\,l\,(\frac{l}{h}+5)} + 0.25$

THE WELD FORMULA (3) *For Reinf Conc Arches*

(*Eng. Rec. Nov 4, 1905.*)

Thickness at Crown in Inches = $t'c = \sqrt{l} + 0.1\,l + 0.005\,W + 0.0025\,p$

l = Span in feet, w = uniform Live Load in lbs per sq. ft p = Dead Load above crown in lbs. per sq. ft.

THE LUTEN FORMULA (4) *for Reinf Concrete Arches*

Crown Thickness in Inches = $t'c$

$$= \frac{3l^2(h+3F)}{4000\,h - l^2} + \frac{W l^2}{3000h} + \frac{W_c(l+5h)}{150h} + 4$$

l = Span in Feet. h = rise in Feet F = Depth of Fill at Crown in Feet w = Uniform Live Load per sq ft W_c = Concentrated Live Load on single track over half span in tons. Where uniform and concentrated Live Loads are not applied simultaneously, use only the term involving these factors, which is the greatest. For Railroad Bridges the uniform L.L. = 0 and the second term drops out

Fig. 5—Formulas for Determining Thickness of Crown Arches

If the foundations are good the fixed arch will in general be the cheaper, except possibly for a very long span where rib construction with hinges at springing line and crown may be the more economical. For soft and yielding foundations the hinged arch should be used for the reasons cited under classification. The three-hinged arch is usually very expensive and is therefore not much used except in cases of very poor foundations, where settlement is anticipated.

LOADINGS TO BE USED IN DESIGN

Arch rings should be investigated for:

1. Dead load.
2. Dead load and greatest possible live load on half span.
3. Dead load and greatest possible live load on whole span.
4. Dead load and greatest possible live load on quarter span each side of center.
5. Dead load with concentrated live load over the portion of the arch where the resistance line as determined by Case 1 rises near the upper edge of middle third.

The maximum live load over one-half span produces the maximum bending moment and over entire span gives the maximum thrust.

In earth-filled spandrel arches little allowance need be made for impact due to moving loads, but for open spandrel construction and especially where subjected to railroad traffic, the arch should be investigated for concentrated loads with impact allowance.

Live Loads.—For earth-filled spandrel arches the designing live loads are generally assumed at 150 lb. per sq. ft. for very heavy highway traffic, while for railroad traffic the practice varies considerably from about 400 lbs. per sq. ft. to 1,000 lbs. per sq. ft., depending upon the span and the weight of engines, as later explained. If open spandrel construction is used, the concentrated loads of vehicles passing over the structure will in many cases give the maximum stresses in the deck construction and they should therefore be used in design.

For earth-fill spandrel arches for

railroad traffic the general practice is to use a uniform live load equivalent to Cooper's standard loadings varying from Cooper's E-40 to E-60, in order to simplify the work of design. The following table gives the uniform live loads per lin. ft. of track for various spans which are equivalent to using the actual wheel loads for the various loadings.

Span	Cooper's E-40	E-50	E-60
40′	6,500 lbs.	8,125 lbs.	9,750 lbs.
80′	5,400 lbs.	6,750 lbs.	8,100 lbs.
100′	5,200 lbs.	5,500 lbs.	7,800 lbs.
150′	5,000 lbs.	6,250 lbs.	7,500 lbs.

Now the width over which the track load will be distributed by the fill will be greater than the length of the ties and will depend upon the depth of the filling. The usual assumption of lateral spread of load is at 45° and for the usual fill of not less than 2′ 6″ at the crown and for 8-ft. ties the load would be distributed a minimum distance of 13′ transversely, or, dividing the values in the above table by 13 we have for 100-ft. span, uniform live loads of 400 lbs., 500 lbs. and 600 lbs. per sq. ft. for Coopers' E-40, E-50 and E-60 live loads respectively. Where the spandrel filling is not very deep (less than mentioned below) a percentage of the live load should be added for impact—in general, about 25% or 30%. As a rule, however, the filling, except on open spandrel bridges, will be deep enough, except possibly for a short distance at the crown, to dissipate the effect of impact.

As to the proper depth of filling at the crown for railroad arches, practice varies considerably. As a result of the tests made by the Austrian government in 1895, a minimum thickness of ballast of 3′ 3″ was recommended. The usual American practice has been to allow about 4′ from top of arch to base of rail, although the tendency with increasing use of railroad arches now seems to be toward a decrease in the depth of filling, especially on open spandrel bridges. The gain by decreasing the depth of filling is in general offset by the additional load which must be allowed for, due to impact of moving loads, and it is, therefore, unwise to decrease the depth of filling too much.

For "Class A" bridges, those on main thoroughfares leading from large towns, the American Concrete Institute, Committee on Highway Bridges, recommends that the design be made for 25-ton trucks with axles about 10′ on centers, with 17 tons on the rear axle and eight tons on the front axle, with the wheels 5′ on centers, this truck assumed to cover an area of 8′ x 35′, the remainder of the bridge to be covered with a uniform load of 125 lbs. per sq. ft. In large cities two such trucks should be assumed as passing each other on the bridge, while for country bridges only one need be assumed as being on the bridge at one time. Such loads as these will produce maximum stresses in the open spandrel construction, but for the load on the arch proper a uniform load of 125 lbs. to 150 lbs. per sq. ft., spread over the entire bridge or part thereof, exclusive of walks, will be ample. For sidewalks a load of 75 lbs. to 100 lbs. per sq. ft. is ample.

For "Class B" bridges the Committee recommends that the design be made for a 17-ton truck with axles 10′ apart, six tons on the front axle and 11 tons on the rear axle, the truck covering an area of 8′ x 35′, with 100 lbs. per sq. ft. on the remainder of the bridge or part thereof under consideration.

For bridges carrying either urban or interurban electric cars it is recommended that they be designed to carry 50-ton cars on two trucks spaced 20′ on centers, each truck having two axles spaced 7′ center to center, the axle load distributed over three ties.

Railway bridges of open spandrel construction should, of course, be designed for actual train loads, to which they will be subjected rather than by a method using an equivalent uniform load, as is usually done with earth-filled spandrel arches. The present day tendencies are toward heavier equipment of all kinds and the larger railroad systems are using Cooper's E-50 and E-55 live loadings in design, while some are even using Cooper's E-60 loading (Fig. 4). Locomotives with axle concentrations of over 6,000 lbs. are not uncommon and it is, therefore, important that open spandrel arch bridges be carefully investigated for the concentrated loads which are likely to come upon them at the present and also in the future, if the fill on the deck is less than that recommended above.

Dead Loads—The dead loads to be carried by the arch are: the weight of the arch ring itself, the spandrel filling or the spandrel construction, if of the open type, and the pavement. The earth fill is generally assumed as weighing 120 lbs. to 130 lbs. per cu. ft., the concrete 150 lbs. per cu. ft., while the pavement will, in general, average about 12″.

The American Concrete Institute Committee recommends that the weight imposed by the earth filling shall be assumed to be equal to the weight of all the filling vertically above the portion of the structure in question, provided the depth does not exceed one-half the total length of the bridge between abutment faces, in which case the depth of fill should be assumed to be equal to one-half the length of the bridge between abutments. In the case of spandrel filled arches, if two planes inclined at an angle of 30° with the vertical one tangent to the extrados nearest each abutment, shall intersect below the surface of the road, only that part of the filling below said planes should be considered, otherwise the whole of the filling vertically above the arch should be assumed as resting on it.

DETERMINING ARCH THICKNESS AS A PRELIMINARY TO DESIGN

Thickness at Crown—After having selected a tentative curve for the arch ring for given span, some thickness of arch ring at crown must be assumed before the actual work of design can be begun. This has given rise to several empirical formulas, by different authorities, the most common of which are given in Fig. 5. These formulas are designed to give arch sections in which no tensile stresses shall occur or the allowable compressive stress be exceeded. They are based on the dimensions of existing arches of masonry and concrete which have carried the superimposed loads without sign of failure.

Due to difference of opinion of the various authorities as to whether an existing arch is too heavy or not, we can naturally expect to find some differences in the results of the various formulas. For example, for a highway arch of 100-ft. span, 40-ft. rise, live load of 150 lbs. per sq. ft. and 200 lbs. per sq. ft. filling at crown, the required thickness is, according to the Douglas formula, 2.84′; by the Frye formula, 2.50′; by the Luten formula, 2.12′, and only 1.8′ by the Weld formula, these last two being for a reinforced concrete arch, while the others are for plain concrete arches. However, since this thickness is used only to lay out the arch as preliminary to the actual design, a slight difference in the assumed thickness at the crown is of little consequence. For a complete theoretical discussion on determining the proper thickness of any arch the reader is referred to *Plain and Reinforced Concrete Arches*, by J. Melan, translated by D. B. Steinman.

Thickness at Springing—For the thickness of the arch at the springing line, measured radially, Frye gives the formula:

$$ts = tc\,[1 + 0.002\,(\text{Span} + 2\ \text{Rise})]$$

while Douglas adds 50% to the crown thickness for circular parabolic and catenarian arches having a ratio of rise to span less than ¼; 100% for the above mentioned types and three-centered arches having a ratio of rise to span greater than ¼; 150% for elliptical, five-centered and seven-centered arches. For these last types the thickness should be measured on a radial line starting at a point on the extrados, where a perpendicular through springing intersects it.

Heidenreich (*Engineer's Pocketbook of Reinforced Concrete*) gives a novel and practical method of finding the thickness of the arch at any point after the crown thickness has been ascertained. Referring to Fig. 6, the radial lines *rr* are drawn intersecting the neutral axis and perpendiculars are then drawn through this intersection. Then lay off on the perpendiculars to either side of neutral axis one-half crown thickness (neutral axis assumed at center of crown, which is practically correct for plain concrete and symmetrical reinforced arches of proper proportions) *ab* and *ba;* from points thus found draw horizontal lines to intersect the radial lines at points *c.* The thickness at any point is then represented by the distances *cc.*

Thickness of Abutments—Empirical formulas for thickness of abutments measured in feet horizontally at springing line are as follows:

Baker, in *A Treatise on Masonry Construction,* gives the formula:

$$a = 1 + 0.04(5l + 4h)$$

where a = horizontal thickness of abutment, l = span, h = height from top of foundation to springing line.

Trautwine's rule is:

$$a = 0.2R + 0.1f + 2.0$$

where R = radius of arch and f = rise.

In a series of continuous arches most of the piers are made narrow, usually about 2½ to 3½ times the crown thickness in width, and are not assumed to have sufficient strength to resist the thrust from one side without any aid from the thrust of arches on the other side. In order, however, that a whole series of arches (five or more spans) shall not be subjected to danger of collapse on the occasion of one pier or arch failing, it is customary to use abutment piers at every third span or every fifth span, capable of resisting the entire thrust from one adjacent arch. Abutment piers should have a thickness corresponding to that of an abutment without earth filling and are usually made five times the crown thickness of arch, at the top, the exact measurements depending on the direction of the resultant pressure on abutment.

FORCES ACTING ON AN ARCH

An arch is a structure having two supports and so shaped that the resulting reactions at supports for vertical loads will be inclined upward. When the ends are immovable for all conditions of loading it is called a fixed arch, and this type only will be discussed in detail here, since it is the most common type for concrete arches.

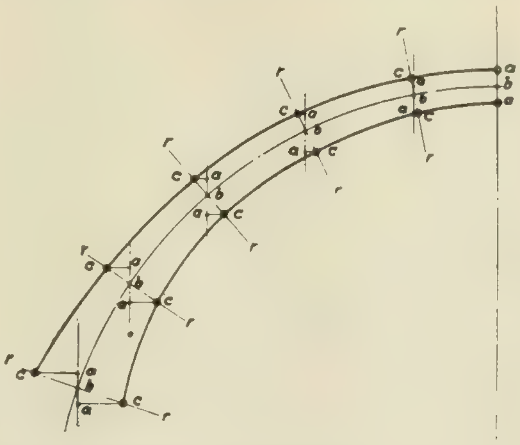

Fig. 6—Graphical Method of Finding Thickness of Arch at Various Points

The forces acting on an arch are commonly known as external and internal forces. The former include the live loads, dead loads of filling or superstructure and arch ring itself and the reactions. The internal forces are the stresses in the arch as computed at various imaginary joints in the arch ring, and may be shearing, compressive and tensile stresses.

In Fig. 7, a longitudinal strip of an arch ring divided into segments or voussoirs by radial lines or imaginary joints resting on fixed abutments, let the external loads applied at center of gravity of sections be represented by P_1, P_2, etc. Then, if we assume that there are no shearing stresses acting in the planes of the sections cutting out the arch strip (true for right arches of homogeneous material uniformly loaded transversely and approximately true for skew arches), each section e. g., Sec. 2-3, is held in equilibrium by the external load P_3 and the resulting pressures R_2 and R_3 on the planes or joints. For stability these forces must hold each other in equilibrium and can, therefore, be represented, in Fig. 7, by the triangle of forces 2-3-0. From this it can be seen that if the load (P_3) and the amount, direction and point of application of one of the resultant joint pressures (say R_3) are known: the amount, direction and point of application of the others can be found successively by the triangle of forces, thereby determining the linear arch as an equilibrium polygon for the given loading.

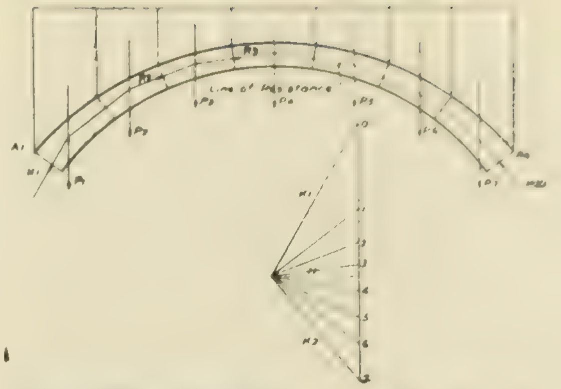

Fig. 7—Forces Acting on an Arch—Line of Resistance

The forces acting at the end planes A and A_1, the skew-backs, are the abutment pressures and the forces opposing them are the abutment reactions K_1 and K_2. Under the application of all the loads P and these reactions K_1 and K_2, the arch is an independent system in equilibrium. The forces R, the action and reaction between the adjacent sections form a polygon called the Line of Resistance obtained by drawing a funicular polygon of the forces P, the outer rays being the abutment reactions and the intermediate rays the resultant joint pressures.

The Line of Resistance changes as the number and directions of sections or joint planes change. In order that no consideration need be taken of sliding at the respective joints or sections, their direction should be such as to be as nearly normal to the joint pressures as possible. This requirement is complied with by placing the joint lines or sections normal to the neutral axis of the arch ring. If an infinite number of sections or joint planes are chosen the line of resistance becomes a continuous curve, and in order to obtain the best results a sufficient number of sections should be chosen to insure a resistance line which very

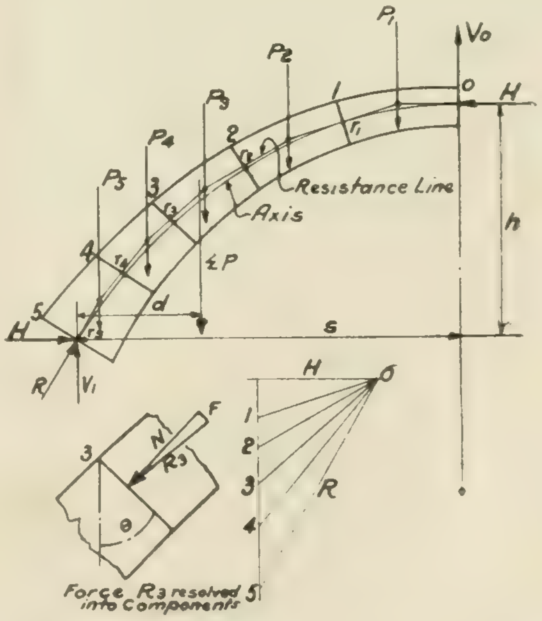

Fig. 8—External Forces Holding Half of Symmetrical Arch in Equilibrium

closely approaches a continuous curve.

In practice no one joint pressure is completely known and, since the equilibrium polygon can be drawn to any scale, it follows that an infinite number of equilibrium polygons can be constructed for a given loading. The particular equilibrium polygon which coincides (or very nearly) with the Line of Pressure of the arch (which is the geometric locus of the points of application of the joint pressure) is the linear arch which fits the case in hand. From this it can be seen that before the equilibrium polygon can be drawn properly, some assumptions must be made as to its points of application of the pressures. The generally accepted criterion for the safety of an arch is that the line of resistance for the given loading shall lie within the middle third of the arch ring. If, therefore, we assume a point somewhat within the middle third at the crown and one within the middle third of the arch ring at each of the skew-backs through which the equilibrium polygon must pass, and with the horizontal thrust *H*, as ascertained by computation as later described, we can draw a funicular polygon with the horizontal thrust *H* as the pole, and after two or more trials obtain a resistance line (by varying slightly the selected points of application), which everywhere lies within the middle third of the arch ring. If after several trials an equilibrium polygon cannot be found which passes through the points selected and at the same time remains within the middle third at all points, the arch ring selected is unsafe and a new one should be laid out. Having found the joint pressures, the stability of the arch ring can be investigated.

Referring to Fig. 8, half of a symmetrical arch, we note that the forces holding it in equilibrium are the applied loads *P*, the horizontal thrust *H*, a vertical reaction *V*, at the skewback and a vertical shear *Vo* at the crown. The vertical reaction *V* is found by taking moments about the right end of the arch, the shear *Vo* is equal to *V*, less the loads to the left of the crown; thus, for symmetrical loading, $Vo = O$.

For symmetrical vertical loading the horizontal thrust can be obtained by taking moments about the point selected at the skewback, using the resultant of the loads times its distance from the point and equating it to the horizontal thrust *H* applied at the point selected at the crown times its arm measured vertically above the plane of the point at the skewback, from which, with Fig. 8, we derive the equation

$$H = \Sigma P \frac{d}{h}$$

METHODS OF FAILURE OF ARCHES

A fixed concrete arch may fail in several ways: (a) By crushing of the concrete. (b) By sliding of one transverse section or voussoir upon an adjacent one. (c) By rotation of one transverse section or voussoir about an adjacent one. (d) By excessive tensile stress in plain concrete. (e) By shearing in a horizontal or a vertical plane. (f) By buckling under column action if the ratio of the unsupported length to its least width is greater than allowable (about 12 for plain concrete arches). (g) By striking the centers before the concrete is able to bear the load brought upon it. (h) By unsymmetrical loading during construction. (i) By settlement or sliding or overturning of pier or abutments.

In order that an arch shall not fail in any of these ways, the forces acting upon it must be in equilibrium and it must possess stability, for the forces may be in equilibrium, as, for instance, just at the point of failure, and still there would be no stability. To prevent crushing of the material, the arch ring must be so proportioned that the allowable compressive stress in the concrete will not be exceeded.

As a safguard, a factor of safety of 4 or 5, or even more, is usually allowed in concrete arches' that is, the average allowable unit compressive stress is only ¼ or less of the ultimate compressive strength. When the joint pressures have been found as described above the compressive stresses can be readily computed by the formulas given and if they exceed the allowable, arch ring thickness must be increased.

As a general rule the resultant joint pressure at any joint is very nearly perpendicular to its plane, and the angle of repose of concrete being very large, failure by sliding is unlikely. To make sure that it will not occur, the resultant pressure should make an angle of less than 30° with the normal to the plane of the joint or section. When the resultant pressure at any joint cuts that joint outside the middle third tension occurs at the edge of the section farthest from the point of application of pressure and the sections tend to rotate about each other. The arch can, therefore, be rendered stable in this particular by proportioning the arch ring so that the line of resultant pressure at all points lies within the middle third.

Failure by tension can be prevented by proportioning the arch so that the resistance line for all conditions of loading lies within the middle third of ring. In reinforced concrete arches this criterion need not be adhered to strictly, since sufficient steel can be provided to care for the stresses, if not too great. High arches tend to shear in a horizontal plane and low arches in a vertical plane. In general, if the shear is within proper limits at points near the springing line of arch no shearing failure will take place. To prevent buckling under column action the ring should be widened in order to give the proper ratio of unsupported length to width, or battered from crown to abutments so as to give the proper ratio. Failures by premature lowering of centers and unsymmetrical loading during construction can be avoided by careful supervision and inspection.

By far the greatest number of arch failures can be laid to unsatisfactory foundation conditions, and pier and abutment design. To guard against settlement the foundations should be as nearly unyielding as possible and the allowable unit bearing values on soil should for this reason be considerably less than those ordinarily used for other structures. To prevent sliding the product of the vertical load on foundation and the co-efficient of friction of the concrete with the rock or soil should be greater than the horizontal thrust. Sliding can be prevented by increasing the frictional resistance by means of keyways into the rock or soil, and if piles are used at least some of them should be driven on a batter parallel to the line of resultant thrust. By designing piers and abutments so that the line of thrust lies within the middle third of the foundation, they will be safe against overturning.

THE STATIC METHOD OF ARCH ANALYSIS

The foregoing discussion gives in the main, the method of analyzing an arch by the static method, so called because only the principles of statics are used. This method, which until recent years was used almost entirely for arch design, gives curves of resistance which agree quite closely with those obtained by the new or elastic method of analysis. However, since the maximum unit stresses obtained vary from 5% to 10% as compared with those obtained by the elastic method, all important structures designed by the static method should be checked in accordance with the elastic theory by which the horizontal thrust and its point of application are determined directly. For preliminary investigations of arches the static method is very handy, as will be shown later, and the general outline of the method will therefore be given.

STEPS IN DESIGN BY THE STATIC METHOD

For an earth-filled spandrel arch the method of procedure by the static method is as follows:

(1) Divide the portion above the arch ring into transverse sections by means of vertical lines which are extended radially through the arch ring. For short-span arches it is customary to divide the structure into parts about 5′ wide; thus, for a 100-ft. span 20 parts would be used.

(2) The weight of the masonry and earth and live load for each section one unit (usually 1′) wide is computed, and after reducing the earth to an equivalent height of masonry of the same weight, the load contour is plotted and the center of gravity of the trapezoid bounded by the section lines at the side and the load contour and intrados of the arch section at the top and bottom, located graphically. The load for the section is then considered as acting through this point.

(3) Having found the loads and their line of action, the horizontal thrust can be computed by the formula (8) just given, and the resistance line constructed with the aid of the funicular polygon. Usually the points chosen at crown and skewback through which the line of resistance must pass are at the middle of the section. If under this condition the resistance line passes outside the middle third of the arch ring at any point, the selected points at crown and skewback are shifted one way or the other so as to correct the difficulty. If, after several such trials, a resistance line which remains wholly within the middle third cannot be found, then the arch is unsafe and another should be laid out. The resistance line should also be laid out which passes through a point at the upper limit of the middle third at the crown or skewback and the lower limit of the skewback or crown and the resulting stresses investigated.

(4) Resistance lines should in general be drawn for the following conditions of loading, subject, of course, to additional conditions necessary on account of the particular loading in question. (a) Full dead load. (b) Full live load and dead load on either span. (c) Dead load over entire span and live load on half span. The use of open spandrel construction demands investigation of the arch for other conditions of loading as stated under loadings to be used in design.

(5) After the resultant pressures are obtained the distribution of stresses at the various sections can be found by the formulas given in the following, which are equally applicable to pressures found by the elastic method.

In the static method of arch analysis temperature stresses, which are often considerable, especially in open spandrel construction, are ignored, as are stresses due to rib shortening. For this reason the elastic theory is preferable, since the above mentioned stresses are given due consideration. Then, again, if the lines of action of the loads are other than vertical they may be more readily treated by the method of the elastic thory.

INTERNAL STRESSES IN AN ARCH (PLAIN CONCRETE)

Having found V_o and H by the formulas given in the preceding the components of the resultant pressure R at any joint or section can be readily obtained (see Fig. 8). The component F, parallel to the joint, is given by the formula

$$F = H \sin \theta - (P - V_0) \cos \theta$$

and N, the component normal to the joint is given by the formula

$$N = H \cos \theta + (P - V_0) \sin \theta$$

In these formulas P is the sum of all loads between the crown and the joint in question and Θ is the angle which the joint section makes with the vertical.

The shearing stresses are found from F but this component is always small if the arch is properly designed for the loading, and can be, in general, disregarded in concrete arches, the relatively high dead load preventing very great variations in the line of resistance.

The normal stresses acting on any section can, for compression within the limits of allowable stress, be computed in accordance with the laws of elasticity of materials. For although the modulus of elasticity of concrete is not constant under varying stresses, within the limits mentioned it may be so assumed without any material error.

For ordinary plain concrete arches where the radius of curvature is large as compared to the sectional dimensions the general formula for extreme fiber stresses in beams subjected to combined bending and direct stress is applicable.

$$f_{1\cdot2} = \frac{N}{A_c} \pm \frac{M c_{1\cdot2}}{I}$$

Where

A_c the area of any section of the arch.

I the moment of inertia of the section about the gravity axis perpendicular to the force-plane.

c_1, c_2 the distance of the upper and lower extreme fibers respectively from the center of gravity.

M = the moment of the joint pressure R, or its normal component N about the gravity axis of the section.

From Fig. 9 it follows that $M = N_c$ where e is the distance from center of gravity to the point of application of the force N. Substituting the value of M and simplifying, equation 11 becomes

$$f_{1\cdot2} = \frac{N}{A_c}\left(1 \pm \frac{e \cdot A_c\ c_{1\cdot2}}{I}\right)$$

For arch ring symmetrical about the gravity axis as for plain concrete section, that is when $c_1 = c_2 = \frac{h}{2}$; and $I = \frac{bh^3}{12}$ the formula (12) may be written

$$f_{1\cdot2} = \frac{N}{A_c}\left(1 \pm \frac{6e}{h}\right)$$

If the thrust acts at the gravity axis there is no bending on the section, the stress being a uniform direct compression over the section, and is given by $f = \frac{N}{A_c}$ the last expression of equation 12 dropping out, since the M is zero.

If the thrust acts at some point within the middle third the compressive stress will have a maximum

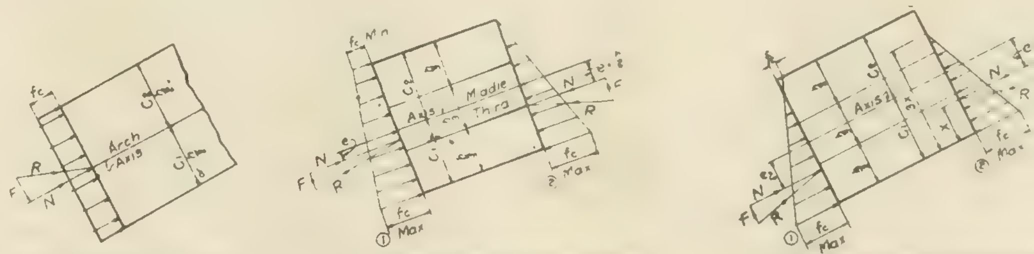

Fig 9a Force Acting at Axis
Uniform Compressive Stress
over Entire Section

Fig 9b Force Acting ① within Middle Third
Variable Compressive Stress over Section
② At edge of Middle Third-Stress Varies
from 0 to Max Compression

Fig 9c Force Acting Outside Middle Third
① Concrete Capable of taking some
Tensile Stress
② Concrete incapable of taking any Tensile Stress

Fig. 9—Stresses in Plain Concrete Arch Sections

value at one extreme fiber and a minimum at the other.

If the thrust acts at the edge of the middle third the eccentricity $e = \frac{h}{6}$ and the maximum compression will be

$$f_1 = \frac{2N}{Ac}$$
$$f_2 = 0$$

When the thrust acts outside the middle third and we allow a limited tension in the concrete, say 50 lbs. per sq. in., the maximum compressive stress will be

$$f_1 = \frac{N}{Ac}\left(1 + \frac{6e}{h}\right)$$

and the maximum tensile stress

$$f_2 = \frac{N}{Ac}\left(1 - \frac{6e}{h}\right)$$

It is the general practice to allow no tension in concrete and for this case the compression acts over a portion of the section and cracks may be expected on the tension side. When these cracks form there is a readjustment of strsses and the compression over the uninjured section is given by

$$f_1 = \frac{2N}{3bx}$$

where b is the width of ring section and x is the distance from point of applicaiton of the thrust to the extreme fiber in compression.

End of Part I

Part II will treat of Stresses in Reinforced Concrete Arch Sections, and the Elastic Theory of Design.

Proportioning Concrete and Checking Quantities for Pavement

The methods of proportioning and checking the materials in concrete sidewalk and pavement construction in Aberdeen, Wn., are described by Louis D. Kelsey, City Engr., Aberdeen, in the *Municipal Journal* as follows:

> In all the concrete pavements and sidewalks laid in this city, only screened sand and gravel have been used. This material is obtained from the bed of the Chehalis river, and the pit material is screened and washed before delivery to the scow.
>
> Our pavements are all of two-course construction, consisting for the most part of a 6-in. base and a 2-in. top. The base contains enough water so that, when tamped, the surface will flush and none of the mortar will be taken by it from the top course after it is placed. This base also makes a solid body upon which the workmen can walk in spreading the 2-in. top, doing away with any chance of the workmen tramping holes in the base and allowing them to fill up with the surface mortar, thus insuring us a straight two-course pavement. The top course is mixed as a very soft mortar that is easily rodded to the shape of the crown desired.
>
> In our lower course we call for 1 sack of cement (94 lbs.) to be used in each 12 sq. ft. of 6-in. base in place. This is based on 1 sack of cement to each 6 cu. ft. of mixed concrete, sand and gravel to be proportioned as 3 to 5, or as directed. The "as directed" clause is placed in our specifications for the reason that our materials vary as to fineness, making it necessary often to shift our proportions of sand and gravel as they require.
>
> In our 2-in. top course we call for one sack of cement in every 14½ sq. ft. of 2-in. top in place, aggregate mixed 1 sand to 2 pea gravel, or as directed.
>
> The inspector can, by checking the subgrade and keeping the base and top to the required thickness at the time they are placed, compute the amount of cement used against the amount required under the specifications. On the work where a boom mixer is used, the inspector takes a check on each move of the mixer, which is about every 20′.
>
> In our concrete sidewalk construction we call for 1 sack of cement to be used in each 24 sq. ft. of 3½-in. concrete base in place, aggregate proportioned 1 sand to 2 gravel, or as directed. This is based on 1 sack of cement to each 1 cu. ft. of mixed concrete. In place of calling for a straight proportion on the ½-in. top for sidewalk work, that is, 1 cement to 2 sand, we limit the contractor to 1 sack of cement (94 lbs.) to be used in each 15½ sq. ft. of sidewalk in place, top and bottom included; the top to be composed of sand and cement in such proportions as will not exceed the limit as set in the specifications for the distance that 1 sack of cement will run. For the most of the sands which we have used, we have found that this is very close to a 1:2 proportion.
>
> This system of specifying how far a sack of cement shall run in concrete pavement and sidewalk construction, we have found, has some good advantages from an engineering point of view.
>
> First: We have found that we can handle a job with only one inspector, whereas in many cities using the other method of mixing—that is, straight proportions—they are using two inspectors, one at the mixer and one at the grade where the concrete is being placed.
>
> Second: From this method of specifying, the contractors, in making up their bids, can compute the amount of cement that is actually required on any certain piece of work, and it also guards against the contractor shaving his price at the time of letting the contract on the theory that he can run a leaner mixture than is called for.
>
> Third: The inspector on the work, after once adjusting the proportions of sand and gravel desired, has as his duty the watching of the cement, the empty cement sacks, the sub-grade and the placing of the concrete, and by measuring up the base at intervals, can at once detect any change in the proportions of sand and gravel.
>
> Within the last two years we have placed some 20,600 sq. yds. of two-course concrete pavement and 17,000 sq. yds. of concrete sidewalks under this type of specification, and we find that this method of giving us good satisfaction.

Building in the Burnt Area of Colon

Extensive rebuilding is in progress in the city of Colon, in the area devastated by fire April 30, 1915.

The fire destroyed 430 buildings on 215 lots, in an area of 22 blocks covering 19½ acres, about a third of the built-up part of the city.

Between 25 and 30 buildings, all of non-inflammable material, are being erected, and up to Monday, Aug. 9, the permits issued for construction in the burnt area numbered 40. The first permit was issued June 10. None of the new houses has been completed. Ten will be one story in height and the remainder two stories. On the basis of a cost of construction approximating 15 cts. per cu. ft., close to $400,000 worth of building is now in progress, in charge of seven or eight contractors.

Four of the houses will be of metal lath and stucco, nine of reinforced concrete construction, and the remainder of plain concrete, in block or poured into forms. The builders are Panamanians, Americans, British subjects and Chinese. Some of the buildings will cover two, three, or even four lots (one instance) and the entire 40 will occupy an aggregate of 62 lots.—*Canal Record.*

Puzzolan Mortars in Sea Water

The *Annali Chimical Applicata* publishes a recent paper by G. Giorgis and G. Cenni. The subject is the behavior of puzzolan mortars in sea water and the results of the experiments as summed up are substantially as follows:

> Samples of puzzuolana mortars which had been immersed in sea water—one from about 60 A. D. and five others from 1886, 1888, 1893 and 1897, respectively—were analyzed. Comparison of the results with the probable composition of the original mortars showed that in all cases a portion of the lime had been removed from the mortar by the action of sea water, but that after some time this action had ceased, for the percentages of lime remaining was of the same order in the sample dating from 60 A. D. as in the others. The quantity of alkalis had diminished in all cases, while that of magnesia showed no appreciable change in four samples and an increase and decrease respectively in the two others.

Making Concrete Tile for Use in Western Alkali Soils

Elsewhere in this issue reference is made to Technologic Paper No. 44 of the U. S. Bur. of Standards: *Investigation of the Durability of Cement Drain Tile in Alkali Soils.* Among other things the publication describes in detail how the tile for test were made. It is believed that well made tile will not be disintegrated by alkali. It is known that poorly made tile are disintegrated by alkali. After only 1 yr. of the 10-yr. series of tests to be made, some information of great value to manufacturers is available. Excerpts are here made from the Introduction of Technologic Paper No. 44 and the description of the methods of manufacture are quoted quite fully. The conclusions after the first year's tests are also quoted.

INTRODUCTION

The disintegration of concrete when exposed to strongly alkaline soils and waters in arid regions of the western part of the U. S. has been a subject of discussion by engineers and users of cement for the past 10 yrs. or 15 yrs. There are many concrete structures in these districts which do not appear to be affected by the salts, but there are some which were apparently made of good materials and were well fabricated which show indications of being attacked.

There are many engineers who believe that well fabricated concrete will not disintegrate when exposed to these alkali salts and that many cases of failure which have been reported have not been caused primarily by the alkali but resulted from the use of poor aggregate, improper methods of fabrication, or other causes which resulted in a poor quality of concrete.

A laboratory investigation was started in 1908 by the technologic branch of the U. S. Geological Survey to determine the effect of alkali waters on cements and concretes. In 1910 this work was transferred, by act of Congress, with all structural materials investigations, to the Bur. of Standards. The investigations were continued and the results were published in 1912.[1] Briefly, these investigations showed that practically all cements are attacked by alkali waters upon exposure in the laboratory, and complete disintegration can be obtained under certain conditions. Similar investigations have been made by other laboratories with similar results.[2]

Disintegration in the laboratory can apparently be obtained in two ways. If the cement specimen is somewhat porous and it is constantly supplied with a salt solution which is permitted to crystallize in the pores, disintegration may result from the mechanical force exerted. If hydrated cement is brought into intimate contact with certain sulphate or chloride solutions, the uncarbonated lime of the cement is subject to comparatively rapid solution, with a resulting decomposition of the cement. Laboratory tests, however, must always be interpreted with caution, as conditions often differ somewhat from service, and it is on this account that a field investigation was undertaken in which cement mortar and concrete mixtures of various qualities could be brought into intimate contact with alkali salts under natural conditions.

The Bur. of Standards has made a field survey of concrete structures exposed to alkali waters in several of the western states. There is a tendency for the cement user to attribute to alkali all failures occurring in these districts, if any alkali is visible in the surrounding soil. Therefore, such failures as occur in the eastern part of the U. S., due to poor materials or improper methods of fabrication, are often excused in the irrigated districts as failures due to alkali.

There are then cited with illustrations numerous instances of failure due, or supposedly due, to alkali.

The present investigation, which is to continue for a number of years, involved the manufacture of 8,800 tile of 16 varieties. This covers the period from July, 1913, to Sept., 1913. Shipments were made in Oct. and the tile were installed in operating drains on eight projects in the most concentrated alkali soils available in the West and for comparison, on other projects, where there was practically no alkali. The locations are: Alkali projects: Garland, Wyo.; Fort Shaw, Mont.; Huntington, Utah; Sunnyside, Wn.; Yuma, Ariz.; Roswell, N. Mex.; Grand Junction, Colo.; Montrose, Colo. Fresh water projects: Crookston, Minn.; Columbia, Mo.

On each project are samples of tile of all the varieties from the leanest to the richest mixtures. One set of tile of each type was stored in the open, exposed to the atmosphere at Ames, Ia. The program requires the removal for test and inspection of two tile of each variety from each project each year for 10 yrs., enough having been installed to make this possible.

MANUFACTURE OF DRAIN TILE

Factory and Equipment—The cement test pieces used in this investigation were made at the tile plant of the Armstrong Cement Works, Armstrong, Ia. The factory has for a number of years been producing large quantities of cement tile, varying in size from 4" to 30", for use in northern Iowa.

The factory building consists of a concrete block and frame structure, which houses the mixers and tile-making machines, with a large low-roofed concrete block addition to one side, which is divided into curing chambers. A railroad switch used for the delivery of materials and shipment of the finished product parallels the building on the opposite side.

Sand is received in dump-bottom coal cars and dropped into a pit, from which it is drawn by a chain drag to the foot of a bucket elevator. After being elevated the sand is dropped into either of two storage bins, or is carried overhead on a belt directly to a sand-storage box, placed above the hopper of a batch mixer. In making commercial tile this hopper is filled with sand to a fixed height, depending upon the proportions desired, and the cement is added. The gate is then opened and the material passes into the batch mixer, which consists of a cylindrical steel drum mounted on rollers. The interior of the mixer contains scoops or buckets, which carry the material up and drop it during rotation. This mixer is very satisfactory in use, mixing the sand and cement uniformly and quickly, but the time required varies considerably, due to the varying amounts of moisture in the sand. A very damp sand generally requires two or three times as many revolutions of the mixer as does a dry sand.

After the cement and sand are thoroughly mixed dry the mass is dropped into another hopper just above a continuous mixer or pug mill. As the dry material is fed into the upper end of the trough of the pug mill, water is sprayed in through a perforated pipe, the amount being reglated by the man at the mixer. To obtain a uniform mixture an experienced man is required, as the rate of feed of the material and the amount of moisture in the sand vary constantly.

This factory is equipped with several tile machines, the Schenck[3] being used in making all the experimental machine-made tile. This machine is of the revolving packer type, the tile being formed between the stationary metal jacket and the packer, which is drawn upward and out of the tile as it revolves.

The car system is in use for handling the smaller sizes of tile after molding. The equipment consists of a suitable number of three-deck cars equipped with springs and roller bearings, transfer trucks and trackage into the curing chambers and out to the various points in the storage yard.

Steam curing of concrete products is used exclusively for curing the regular output of this factory, but all rooms are equipped with water pipes for sprinkling the product, which was the method desired for several of the series of our experimental tile. Cars containing small tile are pushed into low-roofed block-walled rooms, about 90' long, holding 11 cars, with enough clearance on one side to allow a man to pass along the cars and sprinkle the tile. Large tile, wheeled on carts, are cured in two large rooms having concrete floors. Exhaust steam from the engine of an electric lighting plant, owned by the same company, is piped to the various rooms and utilized for curing. Steam was available 16 hrs. per da.

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[1] Technologic Paper No. 12, "Action of the salts in alkali water and sea water on cements"

[2] Montana State Agricultural College, Circular No. 8, 1910; Bulletin No. 81, 1910. Colorado Agricultural Experimental Station, Bulletin No. 132

[3] Cement Tile Machy. Co., Waterloo, Ia.

Materials—The cement used in this work was Hawkeye brand Portland cement.[4] Approximately 240 bbls. of Portland cement were required. For the manufacture of series 15, a sand cement was supplied by the U. S. Reclamation Service, from the sand-cement mill in operation at Arrowrock, Idaho.[5]

The sand used was shipped in from Mason City, Ia., being the material regularly used in the factory.[5]

The water was pumped from a well at the factory. Power was furnished to the entire equipment by a 20-h. p. electric motor, receiving current from the electric lighting plant.

Machine-made Tile—These tile made on the Schenck cement tile machine are 12¼″ in length, ¾″ thick, with an inside diam. of 8″.

Sand was brought to the proportioning hopper, as stated above, except that it was first dropped into a large box placed on a platform scale on the upper mixing platform. All proportions were determined by weight, every batch of sand used being weighed and then dropped into the hopper above the batch mixer, where the cement was added. The material was then dropped into the batch mixer, which revolved continuously, the slide of the hopper again closed, and another batch of the material prepared. Usually one batch would be passing through the pug mill, a second being mixed in the batch mixer, and a third being prepared in the proportioning hopper so that the pug mill could be operated continually to its full capacity.

Usually one man can prepare the batches and keep the pug mill hopper filled, but on account of the extra labor caused by the weighing of the sand two men were used while the "machine" tile were being made. Two men were also required to regulate the water supply and shovel the mixed material into the elevator boot of the machine. One man is required to operate the machine, two men are used in stripping jackets from the tile (which were placed on the car decks only a step or two away from the machine), one man is required in the sand pit and another to push out loaded cars and bring back the empty cars, so that a total of nine men were required to operate the machine at its highest efficiency.

The quantity of water required for various batches of each series was measured by passing the water supply through a barrel whose contents were known for each inch in depth. The amount was then determined by measurement.

Due to the variation in the amount of moisture in the sand and to the use of a continuous mixer in which the water was added, it was impossible to add a predetermined or fixed quantity of water to every batch of dry material. In every case an attempt was made to make the mixture as wet as possible and still allow the immediate removal of the jacket. Too small or too great an amount of water in case of the lean mixtures will cause the tile to crumble or crack in removing the jacket or collapse during the shifting of the car. A rich mixture containing a small excess of water will usually hang together, due to the "stickiness" of the cement, but it is likely to be distorted unless the jacket is stripped with unusual care. Too little or too much water will usually cause immediate trouble at the machine, greatly cutting down the output. The proper amount is indicated very plainly by the web-like markings of neat cement on the outer surface of the tile.

The cars in use hold 97 8-in. tile, but usually the number of good tile was less, due to the sorting out of the culls, which were caused either by the failure of the machine to work properly or by carelessness on the part of the strippers in removing the jackets. This loss can be avoided and the green material remolded if the damaged tile are removed at once.

After placing in the curing room the tile were sprinkled twice, if to be steam cured—once in the evening of the day made and again during the following morning, steam having been turned on during the night. The steam-cured tile were exposed to steam for a total period of 96 hrs., 16 hrs. per da., after which they were piled in the storage yard. The water-cured tile were sprinkled twice daily for a period of 12 das. and then removed and piled in the storage yard.

The temperature of the moist air in the curing rooms varied from 110° to 120° F. during the period in which the steam was on.

The water-cured tile were allowed to harden under much more favorabe conditions than are usually understood by the term "water curing." Too often "water cured" means that tile are stored in an open shed, or, at best, in a large room containing many doors and windows, and sprinkled one or more times a day. In the case of these experimental water-cured tile the cars were run into the long, narrow curing rooms which are continually damp, with wet floors, and perfectly protected from the sun and air currents. The amount of evaporation under these conditions is small compared to that in a large room or shed.

Hand-made Tile—The hand-made tile were made of two types, the semi-wet series and the wet series. These tile have an inside diam. of 8″, with smooth walls 1½″ thick and 12¼″ long, made in sheet-metal molds provided especially for this work. The great difficulty in the use of such molds is in keeping the core centered so that the walls of the resulting tile will be of uniform thickness. Several methods were tried to secure the proper results, and the one found simplest and most satisfactory consisted of a wooden base with two concentric circles of small headless nails projecting up about ⅜″ above the boards. These nails were placed on the inner and outer circumference of two circles having diam. of 8″ and 11″, respectively. This arrangement provided for the centering of the lower end, but it required careful use of the tamping iron to obtain a uniform wall thickness at the top. Molds made of heavier metal would be more satisfactory in this respect, but the cost would have been excessive for this experimental series.

The process of proportioning and mixing of the materials up to the addition of the mixing water was in every way similar to that of the machine-made tile.

Series 1, 3, 4, 5 and 6 were of the plastic consistency, containing as much water as would allow the immediate removal of core and jacket. However, it was found that the material for these hand-made tile had to be slightly drier than that which could be used on the machine, probably due to less pressure being exerted in hand tmaping, making the tile less dense.

The semi-wet hand-made tile were molded on the concrete floor of one of the large curing rooms and were sprinkled in the evening of the day molded. The following morning they were again sprinkled and then placed on cars and shifted into the low-roofed curing rooms, where the steam or water treatment was continued for the proper length of time. In the manufacture of series 6, 10% of ferrous sulphate, by weight, was added to a known weight of water in the measuring barrel, and this solution, kept well stirred, was used in mixing.

The tile of series 14 and 15 were made of a much wetter consistency than those of the other series. These tile contained sufficient water so that they could be easily poured into the mold from a small bucket. The tamping iron was used along the walls of the mold to aid in removing air bubbles from the surfaces. The tile of series 2 were of an intermediate consistency, and required considerable tamping in small layers in order to prevent the formation of "rings" or roughened surfaces. The tile of these series were piled in one of the long curing chambers and sprinkled twice daily for at least 10 das.

Consistency of Mixtures Used—The following consistencies were used in the manufacture of the tile:

Plastic—As much water was added to the dry-mortar mixture as would permit the immediate removal of the jacket from the tile. This condition is indicated by the web-like marks of neat cement and water on the outer surface of the wall. This consistency was used for making the tile of series 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 16.

Quaking — Moisture could easily be brought to the surface by tamping. The material would settle about ⅜″ in the mold during the first 2 hrs. after molding. This consistency was used for making the tile of series 2.

Fluid—This material was of such a consistency that it could be easily poured into the mold. It would settle ½″ to ¾″ in the molds during the first 4 hrs. after molding. This consistency was used for making the tile of series 14 and 15.

DETAILED DESCRIPTION OF EACH TYPE OF TILE

Following is a description of the tile of each of the various series, together with any notes on manufacture peculiar to each:

Series 1—Proportions, by weight, 1 part Portland cement to 2½ parts sand, plastic consistency, hand-tamped, and cured by sprinkling. An average of 7.7 tile was obtained from each bag of cement.

Series 2—Proportions, by weight, 1 part Portland cement to 2½ parts sand, quaking consistency, hand-tamped, cured by sprinkling with water. An average of 7.2 tile was obtained from each bag of cement.

Series 3—Proportions, by weight, 1 part Portland cement to 2 parts sand, plastic consistency, hand-tamped, stored in air for first 24 hrs., then a total of 102 hrs. in steam. An average of 7.6 tile was obtained from each bag of cement.

Series 4—Proportions same as series 3. Cured 24 hrs. in air, then dipped in neat cement grout, loaded on cars and exposed to steam for a period of 102 hrs. An average of 6.9 tile was obtained from each bag of cement, allowing for cement required for grouting.

Series 5—Proportions and method of curing same as series 3. Tile then stored in yard and dipped in boiling tar when 6 wks. old.

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[4] Iowa Portland Cement Co., Des Moines, Ia.

[5] The report as published shows tests of both cement and sand

An average of 7.2 tile was obtained from each bag of cement.

Series 6—Proportions and method of curing same as series 3, except that 10% of ferrous sulphate, by weight, was added to mixing water. An average of 7 tile was obtained per bag of cement.

Series 7—Proportions, by weight, 1 part Portland cement to 3 parts sand, plastic consistency, machine-made, steam-cured. These tile were loaded on cars and placed in the curing chambers immediately after making. Steam was turned on within a few hours and continued for a total period of 96 hrs. An average of 14 tile was obtained per bag of cement.

Series 8—Proportions, by weight, 1 part Portland cement to 4 parts sand, plastic consistency, machine-made, cured in steam for a total period of 96 hrs. An average of 18.8 tile was obtained per bag of cement.

Series 9—Proportions, by weight, 1 part Portland cement to 1½ parts sand, plastic consistency, machine-made, cured by sprinkling with water for a period of 12 das. An average of 8.7 tile was obtained per bag of cement.

Series 10—Proportions, by weight, 1 part Portland cement to 1½ parts sand, plastic consistency, machine-made, cured in steam for a period of 96 hrs. This series differs from series 9 only in the method of curing. An average of 8.7 tile was obtained per bag of cement.

Series 11—Proportions, by weight, 1 part Portland cement to 3 parts sand, plastic consistency, machine-made, cured by sprinkling for a period of 12 das. This series differs from series 7 only in the method of curing. An average of 13.7 tile was obtained per bag of cement.

Series 12—Proportions, by weight, 1 part Portland cement to 4 parts sand, plastic consistency, machine-made, cured by sprinkling for a period of 12 das. This series differs from series 8 only in the method of curing. An average of 18.4 tile was obtained per bag of cement.

Series 13—Proportions, by weight, 1 part Portland cement to 2½ parts sand, plastic consistency, machine-made, cured in steam for a total period of 96 hrs. An average of 12 tile was obtained per bag of cement.

Series 14—Proportions, by weight, 1 part Portland cement to 3 parts sand, fluid consistency, hand-tamped, cured by sprinkling for a period of at least 12 das. Greater part of settling of material in molds took place during the first hour, after which the molds were refilled with some of the same material tamped and troweled. An average of eight tile was obtained per bag of cement.

Series 15—Proportions, by weight, 1 part sand-cement to 3 parts sand, fluid consistency, hand-tamped, cured by sprinkling with water for a period of at least 10 das. Molds refilled with same material, tamped and troweled, after settling had taken place. These tile required very careful handling when the molds were removed the day after molding to avoid breakage. An average of 7.4 tile was obtained per bag of cement.

Series 16—Proportions, by weight, 1 part Northwestern States Portland cement[6] to four parts sand, plastic consistency, machine-made, cured in steam. This series, which was taken from the stock pile of the Armstrong Cement Works, represents the regular commercial output of this factory. No especial care was used in selection, except to throw aside tile which were cracked or had jammed ends. The exact age of this series is uncertain, but the tile are probably at least 6 mos. older than those of the preceding series.

The machine-made tile varied in weight from 23 lbs. to 25.25 lbs., averaging 24 lbs.; the semi-wet hand-tamped tile varied in weight from 42.25 lbs. to 45 lbs., averaging about 43.2 lbs.; tile in series 15, sand-cement, averaged about 41.5 lbs.

The appearance varies with the richness of the mixture as well as the method of molding. Of the machine-made series, 9 and 10, the richest, are lightest in color with more of a glazed appearance while the leaner mixtures are darker in color and have more of a sandy, roughened appearance. In the hand-made series, No. 15 is nearly white, with a "chalky" appearance, due to the use of sand-cement. In series 2, 14 and 15 the hand-made tile of quaking and fluid consistency have rather smooth surfaces with numerous small and shallow indentations due to air pockets on the walls of the molds. The plastic mixtures of the hand-made tile series 1, 3 and 6 have rough surfaces as a rule and in a few cases irregular and insufficient tamping was indicated by the appearance of circumferential rings of porous appearing concrete.

Throughout this work no departure from the regular processes in use at this plant were made except that the proportions were varied and all the materials were weighed to insure uniformity. No specially chosen aggregates were used, the sand being that used in the factory for the manufacture of all kinds of cement products and the cement being purchased under bids with the requirement that it was to pass the U. S. government specification for Portland cement. Although some of the mixtures contain more cement than those in ordinary commercial use, and it is not practicable to make a hand-made tile which can compete in price with the usual machine-made tile, any well equipped and managed factory using good materials should be able to turn out a product which is as good in every respect as has been provided for this investigation.

Replacement Tile—The tile supplied to replace those tested during the year 1914 were supplied by the Universal Portland Cement Co.,[7] and were designated by the series numbers 17 and 18. These tile were 12″ in length, of 8″ inside diam., with a wall thickness of 0.8″.

All concrete was machine-mixed, sufficient water being added that the mixture would just hold its shape when piled with a shovel and would not splash out of the molds when agitated. The sheet-metal molds were filled with an excess of material in a funnel attached to the top of the form. The mold was then placed upon the jigging-machine platform and the machine operated for a period of 30 sec. The drop of this platform was $1\frac{3}{32}$″, while the platform made 120 complete trips through this space per min.

Two sizes of aggregate were used, a sand of good quality passing the ¼-in. screen and a gravel passing a ½-in. round opening and retained on a No. 8 sieve. The sample of cement used in the manufacture of these series was lost in transit and the results were obtained on a sample of the same brand of cement which was submitted 6 mos. later. The proportions used were as follows:

Series 17—1 sack of cement to 1½ cu. ft. of sand.

Series 18—1 sack of cement to 2 cu. ft. of a mixture of fine and coarse aggregates, which were mixed in the proportion of 2 parts sand to 3 parts ¼-in. to ½-in. gravel.

The tile were removed from the molds on the following day and then piled in one corner of the laboratory and covered with sand, which was kept constantly wet.

The surface of these tile had much the same appearance of that of the tile of series 2, 14 and 15, since they were made of a quaking consistency.

After these tile had cured for a period of at least 1 mo. they were crated in wooden crates holding six tile each and shipped to the various projects and later installed in the place of those removed for test.

CONCLUSIONS

Details of this investigation and the results of the first year's tests are published at this time because of their economic value in demonstrating to those who are now using or considering using cement drain tile that special care should be observed to employ only the best materials and good workmanship in its fabrication, and if these precautions are not observed failure will result if the drain is located in some of the more concentrated alkali soils similar to those found at Grand Junction, Colo., and Garland, Wyo.

Drain tile manufactured in a manner as herein described for series 2, 9, 10, 11, 13 and 15 of cement mixtures not leaner than 1 part cement to 3 parts of aggregate are apparently unaffected structurally when exposed for 1 yr. in operating drains in very concentrated alkali soils, similar to any of those included in this investigation.

Drain tile made from cement mixtures leaner than 1 part cement to 3 parts of aggregate should not be used in localities where the character of the alkali and concentration are similar to that found at the site of the experimental drains at Grand Junction, Colo., Montrose, Colo., and Garland, Wyo., and it is possible that subsequent results will show that no leaner mixture should be used in any district where appreciable alkali is found.

Drain tile manufactured in the manner herein described of 1 part cement to 4 parts of aggregate, the leanest mixture used, is apparently unaffected structurally by exposure for 1 yr. in an operating drain in localities where the character of the alkali and the concentration are similar to those found at Fort Shaw, Mont.; Sunnyside, Wn.; Yuma, Ariz., and Roswell, N. Mex.

Other than the above, no very general conclusions should be drawn from this investigation until the results of further tests are obtained. It is anticipated that this report will be amended from time to time as the results are available.

The Bureau would be pleased to receive information concerning the behavior of concrete exposed to strongly alkaline soil which may come to the attention of engineers or others interested in the use of concrete under these conditions.

Concrete Pavement 28 Years Old

C. C. Pike, Santa Barbara, Cal., writes that he put down a concrete pavement on State St. in Santa Barbara 28 yrs. ago. He used White Bros. imported cement and did the work in two courses, the top being 1″ thick mixed 1:1 cement and sand. It was put down, alternate blocks at an operation, with tar paper joints. "The top coat was wetted and retempered after setting a short time," says Mr. Pike, "then floated with a wooden float and troweled smooth, with lots of elbow grease. The coarse grains of sand are showing some now and some blocks have been cut for pipes to be laid and reconstructed, but most of it will be good 50 yrs. yet. The next block down there is some paving that has been renewed three times since and needs it again."

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[6] Northwestern States Portland Cement Co., Mason City, Ia.

[7] Chicago

Concrete Work Withstands Severe Tests in the Erie Flood

By Lewis R. Ferguson[1]

Here is a "selling talk" for concrete bridges and other concrete structures, too, for that matter. By a coincidence this follows by only a month the publication of the paper by J. H. Ames, Asst. Iowa state highway engineer, on some bad bridge work in Iowa which contractors are going to replace.[2] This paper by Mr. Ferguson will be ammunition—as Mr. Ames's paper was medicine—for concrete bridge contractors. They can "sell" concrete bridges on the strength of what Mr. Ferguson says and they can then sell more such bridges if they profit by what Mr. Ames said.

The flood at Erie, Pa., has been extensively reviewed in the technical press, but from the viewpoint of the concrete engineer and those interested in allied subjects many important features have been neglected. The effectiveness of concrete construction under stress of fire has been demonstrated on many occasions, but the fact that concrete is able successfully to withstand the action of flood has not been so well demonstrated. Although it is unnecessary to prove this fact to those familiar with the use of concrete, a few illustrations of its great strength and resistance to the forces of water in heavy floods will furnish to those not acquainted with this type of construction convincing evidence of its great durability and strength.

The first newspaper reports of the Erie flood stated that it was due to the failure of a concrete dam on Mill Creek, some little distance outside the city limits. This was later denied and it developed that this Glenwood dam, which is built of reinforced concrete, was in no way damaged, the real cause of the flood being the blocking up of the water at the 26th St. bridge across Mill Creek.

Twenty-sixth St. is at the upper limits of the city; from this point Mill Creek flows in a generally northerly and northeasterly direction for a distance of about 2 mi. though the town. At many of the streets there are bridges of various types of construction. Some are of brick and stone masonry, others being of stone masonry combined with concrete, and in some cases concrete alone is used. The grade of the creek through the upper part of the town is very steep, while at the lower end of the town there is but a slight drop in the creek bed.

The 26th St. bridge was a brick arch, having on the lower side of this arch a concrete retaining wall. The approaches to the bridge were in the form of an embankment about 25′ high. The brick arch was blocked up with the débris from the flood, the water rising to the top of the embankment and causing both the embankment and the brick arch to give way, thus releasing the water impounded back of them. This great amount of water, increasing in velocity and volume as the flood progressed, attacked each of the numerous street bridges in its progress down the valley of Mill Creek until it finally reached the outlet into the lake. A review of the various bridges attacked by the flood and their behavior under this stress will be interesting and instructive to those contemplating construction work which might involve the types of masonry used in these structures.

As previously stated, the 26th St. bridge was a brick arch of about 20-ft. span, on the lower side of which was a concrete retaining wall. This brick arch failed completely, releasing the great flood of water back of it, while the concrete retaining wall, although in a much more exposed position than the brick arch, as the entire flood passed around each side of it, remained entirely intact.

At 23rd St. the creek was spanned by a flat concrete slab about 20′ long, resting at either end on heavy stone masonry abutments. The water literally tore the stone work apart in making its way through this bridge, but the flat concrete slab remained intact and can be used in the reconstruction without any repairs whatever.

At 21st St. the bridge was composed of a brick arch with stone backing and retaining walls. This structure was almost entirely destroyed by the flood.

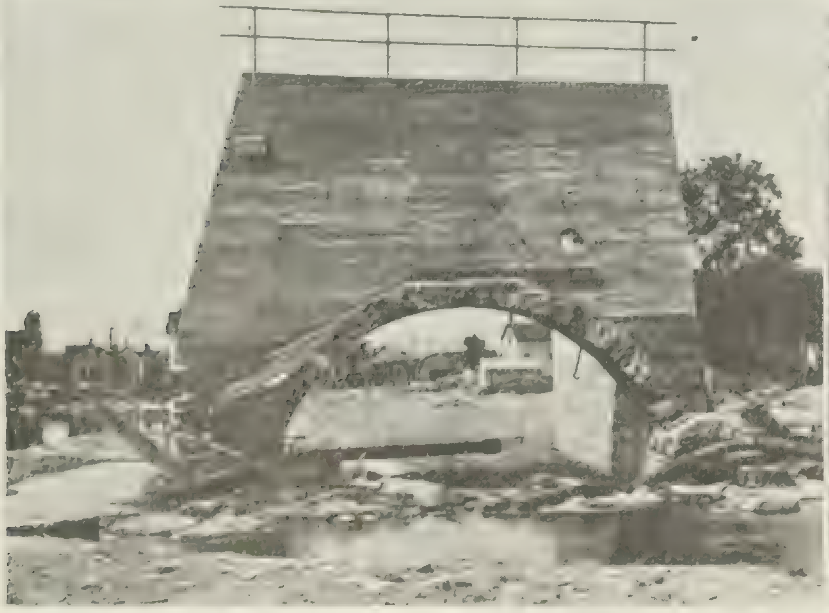

Fig. 1—What Is Left of 26th St. Bridge Over Mill Creek. Concrete Retaining Wall Undamaged. Brick Arch Entirely Destroyed

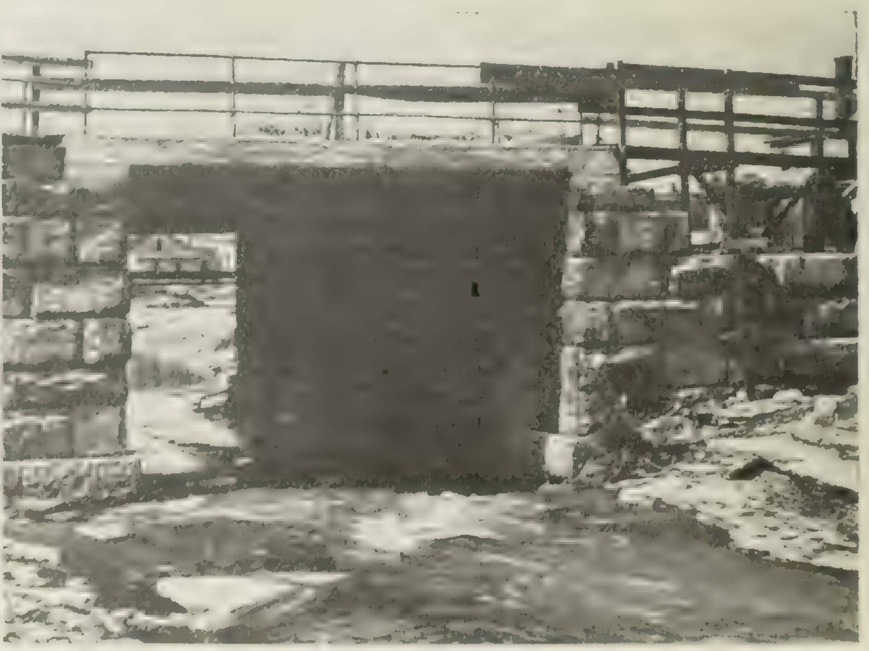

Fig. 2—23rd St. Bridge Over Mill Creek. Flat Concrete Slab Supported on Stone Masonry Abutments. Concrete Not Damaged, Stone Masonry Partly Destroyed by Flood

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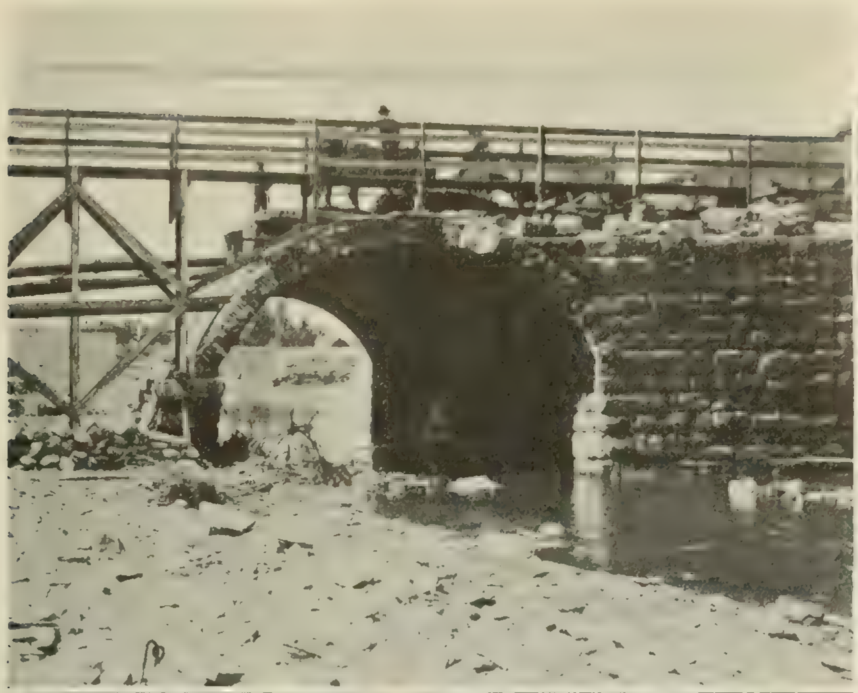
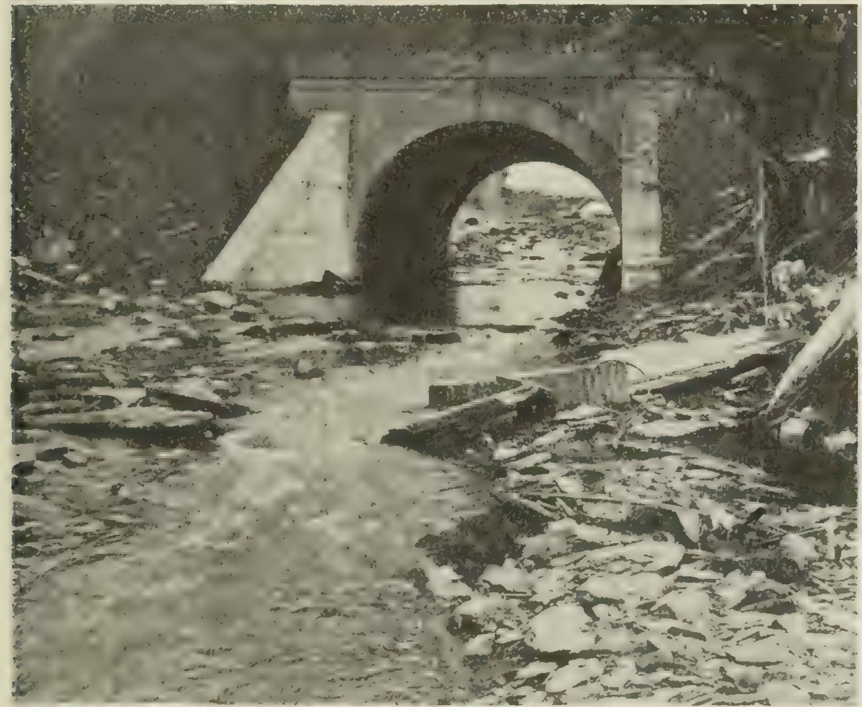
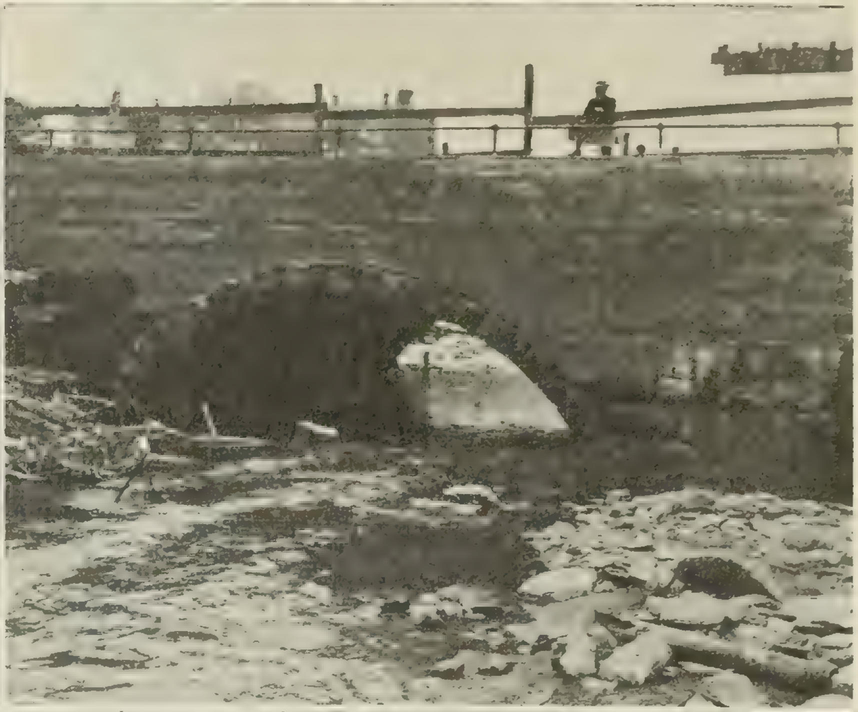
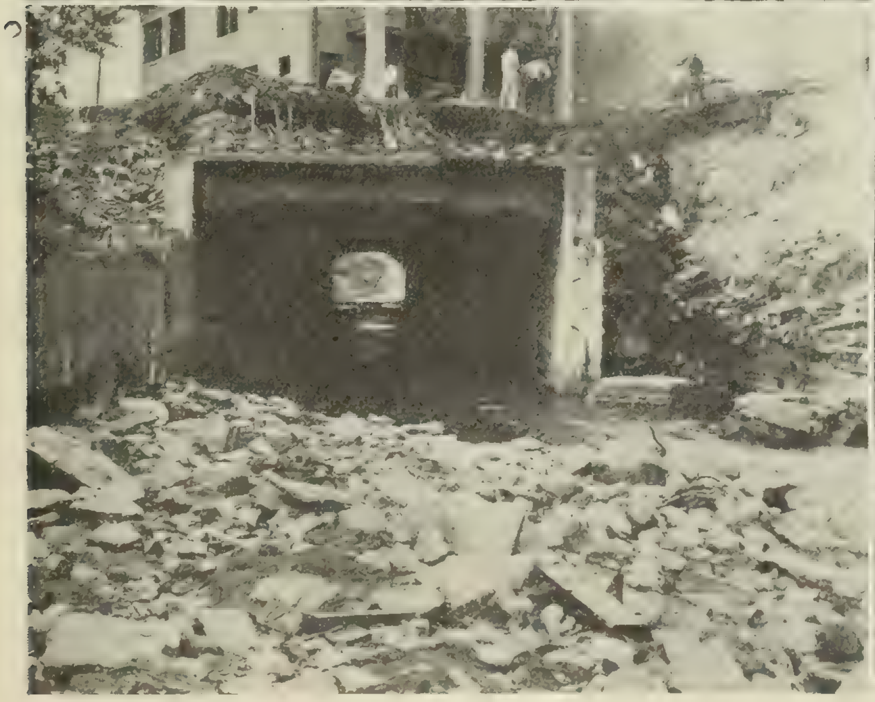
[1] Asst. Secy., Assn. Am. Portland Cement Mfrs., Philadelphia

[2] Concrete, Sept., 1915, p. 104









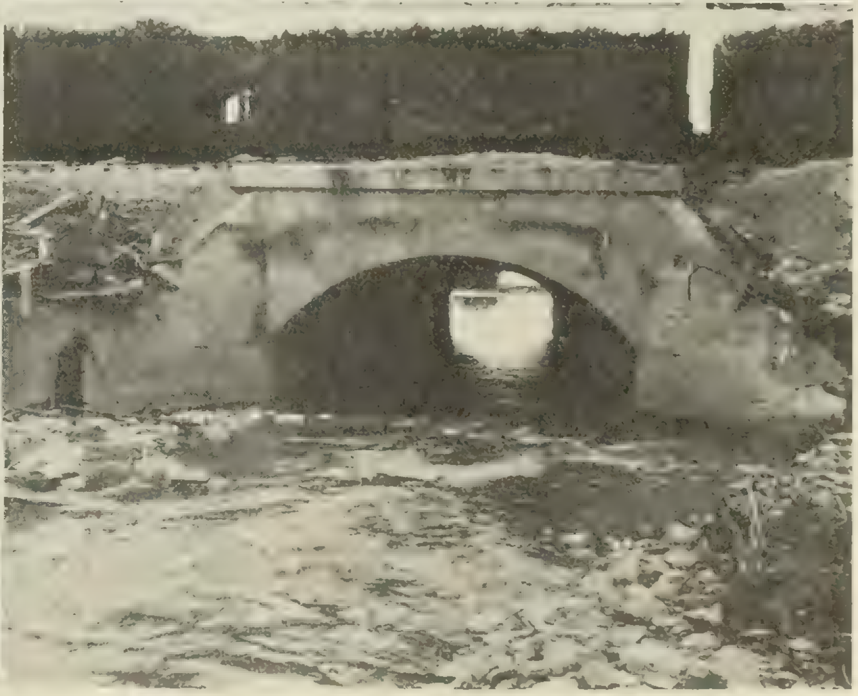


Fig. 3—21st St. Bridge Over Mill Creek. Brick and Stone Entirely Destroyed by Flood

Fig. 5—Erie, Pa. Nickel Plate R. R. Concrete Arch Bridge Over Mill Creek

Fig. 7—Reinforced Concrete Culvert 6th St. and Mill Creek. The Light Concrete Slab Forming the Top of this Arch Was But Slightly Damaged by the Action of this Flood. Needs Only Plastering to Put It In Good Shape

Fig. 4 -Concrete Foundation Wall West Side Mill Creek Above 20th St. Only Seven Days Old at the Time of the Flood

Fig. 6—18th St. Bridge Over Mill Creek. Ashlar Masonry Wing Walls Entirely Destroyed by Flood. Replaced With Concrete

Fig. 8—Concrete Arch, Pennsylvania Railroad, Over Mill Creek. Undamaged by Flood

Just below the 21st St. bridge was a concrete foundation for a new building. The concrete in this work had been in place about a week only and the structure itself extended almost into the bed of the creek, and was, therefore, subject to a very considerable portion of the flood action. It came through the ordeal

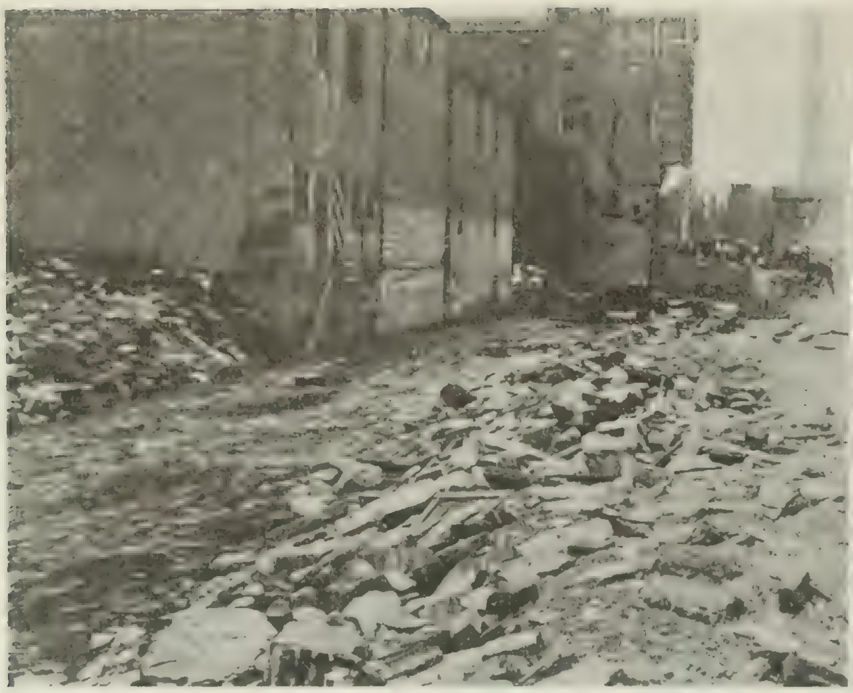


Fig. 9—Concrete Block Houses West Side of Mill Creek and Flat Concrete Arch at 15th St. in the Background. Both Houses and Concrete Arch Undamaged by Flood

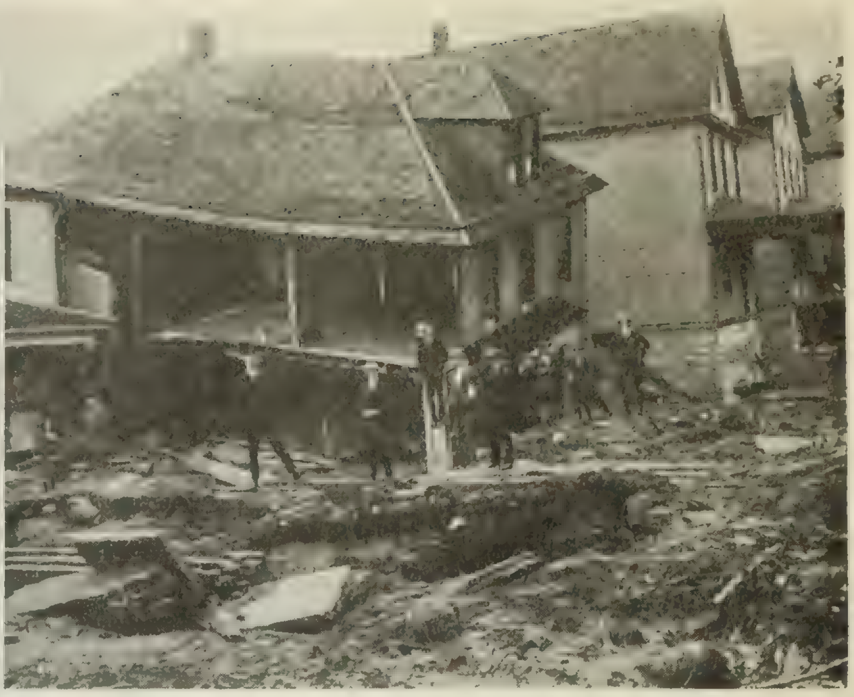


Fig. 10—Frame Buildings Prade St. Below Fourth. Building in Foreground Was on Stone Foundations Which Were Destroyed by Flood. Two Buildings in Background Are on Concrete Foundations and Were Not Damaged

uninjured, however, and is now being used for the foundation of the building which it was originally intended to support.

Still farther down stream is the concrete arch which supported the embankment of the Nickel Plate R. R. This arch became blocked with the débris and the entire railroad embankment over the arch was washed away, but the arch itself remained entirely intact and is now being used, with no repairs whatever, and is again carrying the fill with the railroad trains above it.

That the authorities of the City of Erie fully realize the effectiveness of concrete construction is shown in the next bridge at 18th St., which was formerly a stone arch with stone backing and wing walls. After the flood, although the stone arch remained, the heavy ashlar masonry in the wing walls and backing had entirely disappeared, being carried away by the water. In rebuilding this structure the city is still using the old stone arch, but has rebuilt the wing walls and backing of concrete.

At 15th St. the creek was spanned by a flat concrete arch, which was undamaged by the flood. From this point for the next three-quarters of a mile the bridges were built of various combinations of stone and brick and were all partly or wholly destroyed.

At Sixth St. there is a long reinforced concrete culvert carrying the creek diagonally under the street. Although the top slab of this culvert was but 6″ thick, it was only slightly damaged by the mass of débris carried by the flood, and after a few repairs in the way of plastering and facing, is again in good condition. As the creek leaves the city at the lower end it passes under two railroad bridges, both of which are concrete arches and both of which are in perfect condition.

In addition to the superiority of concrete in construction of massive proportions it is interesting to note the results when used in lighter work, such as houses, foundations and concrete block construction. Between 15th St. and 16th St. there are several houses built of concrete block which abut directly on the creek and which came through the flood undamaged except by such water as gained access to rooms on the first floor. A still more interesting example, however, is shown in the results secured by the use of concrete foundations for frame buildings. On Prade St., below Fourth, were a number of frame houses, three of which were built on concrete foundations, while the fourth one had a foundation of stone masonry. The house supported by the stone foundation was on the down-stream side of those on the concrete foundations, and was therefore partly protected by them. However, even with this added protection, the stone work gave way and the house collapsed and is a total wreck, whereas the same general type of frame buildings on concrete foundations survived intact.

The only cases in which concrete work did not come through the flood successfully were those in which the foundations were defective, causing the walls to topple over, due to no inherent defects in the material itself, faulty foundations alone being responsible.

In contrast to this are bridges of brick and stone, which, when attacked by the flood and the débris which it carried, were torn apart piecemeal, one stone after another, beginning at the top and frequently tearing the work down to the foundation line.

The Erie flood has developed many engineering questions which it will be necessary to solve, such, for example, as the matter of the flow of water from the water shed drained by Mill Creek and the requisite span of the various bridges which will be required to carry off this water safely, but it has settled one matter beyond any doubt or question, namely, the superiority of concrete for practically every type of construction. The standard of construction *Concrete for Permanence* may well apply in this case, but we might add the slogan used by one of the construction companies dealing exclusively with concrete work: *It Is Not Built of Pieces and Will Not Go to Pieces.*

Leave Sodium Silicate Out of the Batch

A reader of this magazine recently proposed mixing a solution of sodium silicate (water-glass) in his batch of concrete instead of applying it to the surface of the work afterward. Albert Moyer[1] says of this: "This cannot be done. When two strong alkalies come in contact with each other, there is an awful fight, and this fight interferes with the cement setting. In fact, it forms a kind of jelly."

Cleaning Concrete and Stone

A wire brush provided with a suitable shank and operated by an electric drill is said to be a cheap and very effective tool for cleaning concrete and stone surfaces. It is probable that this would be an effective device for cleaning forms.

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[1] Vulcanite Portland Cement Co., N. Y. C.

Information and Consultation: The How-to-Do-It Department

This magazine is for service. Let it serve you, and you help it to serve. You want special information. Ask us. We know the men who know.

Probable Life of Portland Cement Stucco on Metal Fabric

THE QUESTION BELOW IS DISCUSSED BY:

A. L. JOHNSON[1]
CLOYD M. CHAPMAN[2]
LEONARD C. WASON[3]
S. W. STRATTON[4]
OSWALD C. HERING[5]
E. K. BORCHARD[6]
JAMES N. KEENAN[7]
J. P. WAGNER[8]
W. C. EDWARDS, JR.[9]
E. D. CODDINGTON[10]
C. S. RENO[11]
C. O. POWELL[12]
T. W. MURRAY[13]
W. G. LANE[14]

"I am trying to collect data on the expected life of such outside walls as are covered with Portland cement stucco plastered on metal lath. Inquiries which I have made among a limited number of engineers and architects have brought a wide range of replies and do not indicate a very long life, estimates running from 3 yrs. to 9 yrs. I should like very much to get some information more definite than this, and should like to hear from those who have had some experience on which an estimate can be made."

BY MR. JOHNSON

THEORY

Plaster used for stucco is composed of Portland cement gauged with sufficient lime to take away its shortness, so that it will run under a trowel. Both Portland cement and lime are excellent preservatives of metal, and if applied directly to the metal, will preserve it indefinitely, even in the open air, unless for some reason cracks develop, or the metal becomes exposed. The exposure may come from shrinkage cracks, or from decay of the paint coating.

Shrinkage Cracks — Most stucco work is cracked soon after erection. In this respect stucco on metal lath is no worse than, and probably not as bad as stucco on tile. The coefficient of expansion of tile is only half of that of Portland cement, whereas the coefficient of expansion of metal lath is the same as that of the cement. Metal lath construction, however, has wood for its support, and while wood has no coefficient of expansion with temperature, it has a very large expansion and contraction with varying moisture content. The interior of stucco walls is, of course, not air tight, and the wood sheathing expands and contracts with the variation in the hygroscopic condition of the atmosphere within this space. This swelling and shrinking of the wood may be as much as $\frac{1}{2}''$ in $12''$ crosswise of the grain, as compared with $\frac{1}{10}''$ in $10'$ lengthwise of the grain. The cracks in the stucco tend to run parallel to, and coincide with, the edges of the sheathing boards. This can be overcome provided the metal lath is heavy enough so that it has a tensile strength in all directions equal to the tensile strength of the mortar for the same width in the same direction.

The presence of the metal reinforcement does not prevent shrinkage of the plaster in falling temperature, and whatever the strength of the reinforcement, the plaster can be pulled in two, unless provision is made at the corners of the building for a slight freedom of movement, such as might be occasioned by the shrinkage due to the drop in temperature for half the length of that side of the house. Some little attention is necessary to this detail so as to furnish a stucco corner that is rigid and yet one not immovably attached to the corner stud, but, as a matter of fact, swung from the next studs on each side of the corner. With such construction it is possible to prevent exposure of the metal reinforcement through the development of shrinkage cracks.

Decay of the Paint—Even in the case described there may still be exposures of the metal through the decay of the paint coating. It would be desirable to use for this work lath that is unpainted, or galvanized, if absolute permanency is required, but it has not been found practicable to ship thin material of this sort entirely unprotected, while galvanizing is too expensive to be generally considered. If the metal is painted, it would be preferable to have the thinnest and hardest coat possible; such, for example, as linseed oil; pure linseed oil would be prohibitive in price for ordinary lath purposes.

The question of paint has been given a great deal of study during the last 25 yrs., and the product today is a vast improvement over what it was even a few years ago. At the same time, my personal opinion as a technical man is that we have not yet arrived at a thoroughly satisfactory solution of the problem.

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[1] Vice-Pres., Corrugated Bar Co., Buffalo

[2] Engr. of Tests, Westinghouse, Church, Kerr & Co., N. Y. C.

[3] Pres. and Mgr., Aberthaw Constr. Co., Boston

[4] Director, U. S. Bur. of Standards, Washington, D. C.

[5] Architect, N. Y. C.

[6] Inf. Bur., Assn. Am. Portland Cement Mfrs., Philadelphia

[7] Engr., Asbestos Protected Metal Co., Pittsburgh

[8] Wagner-Behm Co., Chicago

[9] Pres., Edwards Metal Structures Co., Kansas City, Mo.

[10] E. D. Coddington Mfg. Co., Inc., North Milwaukee

[11] Gen. Sales Mgr., The Consol'd Ex. Metal Co., N. Y. C.

[12] Adv. Mgr., Northwestern Ex. Metal Co., Chicago

[13] Assoc. Mgr. of Sales, Trussed Concrete Steel Co., Youngstown, Ohio

[14] Bostwick Steel Lath Co., Niles, Ohio

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PRACTICE

About two years ago I had occasion to examine a large number of stucco buildings, some having been built many years, some but half completed. Most of them were of the usual type of stucco on metal lath on wood sheathing covered with waterproof building paper, with wood lath used for the furring strips between the metal lath and the waterproof paper. The remainder were generally stucco or hollow tile. I examined 75 or 80 residences and none of them was uncracked. By cracks I do not mean mere crazing cracks due to the fact that the plaster was dried out too rapidly, but a crack that went clear through the ¾-in. coat. On one building, just being finished, the contractor maintained that the crack was only "just a slight crack on the surface," and took a chisel to prove his point, but instead proved to his own satisfaction that the crack went at least as far down as the lath. Not a single residence did we find of whatever type of construction, and in whatever stage of completion, old or young, that was not cracked. Owners often say: "Yes, my house has been entirely satisfactory; the plaster never has cracked at all." On examination, however, we would find that every wall in the building had a number of cracks which they had never noticed.

I cite this to show you that human testimony is of little value except as it comes from experts on matters relating to some particular thing that they have had occasion to investigate thoroughly.

The ordinary lath used for stucco is a very light fabric, and does not begin to have a tensile strength per foot of width equal to the tensile strength of the cement mortar. That is the fundamental principle involved in this matter of the cracking of stucco; but the taking care of this condition is not sufficient of itself to prevent cracks unless the details of the corners are also properly cared for. It is understood that the reinforcement must be of such character that it can be entirely covered by the cement mortar.

EDITORIAL DISCUSSION

The length and number of discussions submitted is such that space is not available for publishing them in full. Following are summarized the opinions expressed by several writers with extensive quotations from them:

1. The structure on which the metal is secured must be exceptionally rigid and well braced. Framing should be so placed as to allow a minimum of shrinkage. Narrow sheathing is preferable and best results are obtained where it is placed diagonally on the studs.

2. Galvanized lath is best, but necessarily more expensive. Improved paints are being worked out that may be satisfactory. Unpainted lath is not generally satisfactory, owing to its likelihood to become badly rusted before it can be covered with mortar.

3. Given a rigid, well braced frame, best results are obtained by back-plastering. If sheathing is used it should be covered with waterproof paper. Furring (preferably metal) should be narrow and should allow the entire space between the lath and the sheathing to be filled with mortar so as to embed the metal completely.

4. Corners must be left free to give with temperature movements. (See discussion by Mr. Johnson.)

5. Stucco must be carefully proportioned, placed and protected according to standard specifications as given by the American Concrete Institute,[14] Assoc. of Am. Portland Cement Mfrs.,[15] the Nat. Lime Mfrs. Ass'n[16] or the Associated Metal Lath Mfrs.[17] (Copies may be obtained free by addressing these organizations.)

6. Special conditions have much to do with the life of stucco, such as exposure near salt water and to fumes from certain industries.

In his discussion, Cloyd M. Chapman says:

> A life of from 3 yrs. to 9 yrs. for ungalvanized lath is about as close an estimate as can be made, the variation being due to the difference in the permeability of the stucco and the character of the exposure. A thin, permeable stucco near the seashore would do well to last 3 yrs.; whereas a good three-coat job of dense stucco under less severe exposure might be expected to last 9 yrs. or somewhat more, but with a well galvanized fabric and fairly good stucco we should expect a life of many years more, probably 15 yrs. and upward.

Leonard C. Wason says:

> It is only a year since a standard specification was worked out, after a number of years of study, by the Am. Concrete Institute, and I believe that a good deal of the work which preceded was of a variable quality and little of it up to this standard, especially as to coating on the lath itself, such as galvanizing or Japan. Therefore, the life of existing stucco must be quite different from that of good workmanship and materials following the recently adopted standard. I have observed, in a general way, a number of houses in my neighborhood which have been built for 8 yrs. or 10 yrs., which appear while passing (although I have not stopped to make a critical examination) to be as good as new.

The U. S. Bur. of Standards has conducted a series of tests with stucco on metal lath and other materials.[18] Mr. Stratton writes:

> The exposure of these preliminary test panels was undoubtedly more severe than that of normal stucco construction, yet the majority of the panels will apparently endure for many years to come. In fact, all of the galvanized lath and much of the painted lath is in practically as good condition after nearly 4 yrs. exposure as when put in place. On this basis, bearing in mind particularly that the lath in these tests is abnormally exposed and that the type of open-back construction used in the tests is no longer recommended by the Am. Concrete Inst. or the Associated Metal Lath Mfrs., we are of the opinion that Portland cement stucco on metal lath, applied in accordance with the specifications of these organizations, should be guaranteed for at least 10 yrs. in a climate similar to that of Washington.
>
> The life of stucco, however, does not depend entirely on the durability of the lath, and the prevention of hair-cracking and consequent disfiguration of the stucco surface is a much more serious problem than the preservation of the metal fabric. Thus local conditions may greatly affect the satisfactory life of stucco, even in cases where the integrity of the lath and stucco as a whole is unimpaired. At the present time we believe there are few experienced builders willing to guarantee stucco absolutely against cracking, and especially hair-cracking, which affects the appearance more seriously than the durability.

The need for expert knowledge and workmanship is emphasized by Mr. Hering, who says:

> On a frame house which I designed 13 yrs. ago a stucco containing Portland cement was applied to metal lath as an outside wall covering and apparently it is in as good condition today as when it was put on. On the other hand, I have seen a poor mixture of stucco, which nevertheless contained Portland cement, crack and tumble off in less than 2 mos. from the time it was applied.
>
> To determine with a fair degree of accuracy the life of stucco, its composition and the manner of its application should be known and the conditions surrounding it since its application.

Mr. Borchard, writing for the Assn. of Am. Portland Cement Mfrs., which has given this subject much attention, says:

> If the stucco is properly applied to metal fabric and is mixed according to standard specifications, it will last indefinitely. In order to prevent the metal fabric from rusting, it must be entirely

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[14] Harrison Bldg., Philadelphia

[15] Bellevue Court Bldg., Philadelphia

[16] Riverton, Va.

[17] 332 S. Michigan Ave., Chicago

[18] See CONCRETE, July, 1914, p. 38

embedded in the stucco. Many failures in stucco work are due to a failure to embed entirely the metal fabric in the stucco.

The rusting of the fabric is in many cases due to the moisture from condensation acting on the fabric from the inside and is not due to the stucco being porous, as is often thought to be the case. This happens when the metal fabric is not properly covered with stucco on both sides.

The importance of taking into consideration local atmospheric conditions and thoroughly embedding the metal is emphasized by Mr. Keenan, who also calls attention to several methods which are certain to result unsatisfactorily. Extracts from his discussion follow:

We know of old frame residences in N. Y. and N. J. which have been covered with stucco on metal lath, and after 15 yrs. and 18 yrs. are apparently as good as when the stucco was first put on. We have seen, in southeastern Ia., stucco on metal lath where patches 4" to 10" long and half that in width have fallen off after 4 yrs. service. Examination of this case disclosed the mesh nailed close up to an old brick wall without any attempt at furring and the lath in many places not entirely embedded in the mortar.

In No. Tonawanda, N. Y., a solid wall made of an inside and an outside facing of mortar on metal lath with the 3-in. space between these facings filled with cinders, partly collapsed after less than 3 yrs. service. When placing the cinder fill in the hollow space, it is conceivable that the plaster was knocked off the inside face of the metal lath, allowing the cinders to come in contact with the lath. In the part collapsed, no lath remained, streaks of rust indicating where it had been.

This company has very recently removed the siding of stucco on lath from a large foundry building within 50 mi. of Pittsburgh, which had been in place about 5 yrs. There were two large revolving cranes inside of this building connected directly with the framework, and these caused considerable vibration. The building was used for molding and pouring large castings and a great part of the time the building was filled with smoke. This foundry was situated in a locality in which soft coal smoke pervades the atmosphere. The removal of the stucco and its replacement by some other material was made necessary by its unsightly appearance and dangerous condition. Large patches had fallen off, especially at corners and around the window frames, and much more was dangerously loose. This lath was plastered on both sides.

In removing the stucco, which in many places was 4" or 5" thick, it was found that only streaks of rust remained in most places. Undoubtedly the destruction here had begun by the vibration opening cracks in the plaster, admitting the rain and smoke-laden atmosphere from the outside and the moisture and foundry gases from the inside, which ultimately destroyed the lath in the short space of 5 yrs.

This company was recently asked to bid on the replacement of the siding of Portland cement stucco on an unpunched lath on some ventilation shafts of a manufacturing plant along the Niagara river. This siding had been in place about 6 yrs. After 4 yrs. service patching had become necessary and had been done. Upon inspection, the writer found several places where the plaster had fallen out, one large hole being about 10' across.

The writer examined several of the metal sheets after they were removed. For the most part they were badly corroded.

There are several causes which may have helped in the destruction of these walls. After the erection of the metal about 2 mos. elapsed before the plaster was applied; this allowed the rust to get a good start.

The ventilation shafts and the house over the bins are about 100' in the air in a location where they are subject to very violent winds, which undoubtedly causes considerable vibration, opening cracks in the plaster. In the ventilating shafts, the gases carried off are at a temperature of approximately 100° F. and come from a floor where a battery of electric furnaces is in operation. This air may contain a slight amount of destructive gas but certainly cannot contain very much, since men work at these furnaces. There are many electro-chemical industries in the locality which probably discharge destructive gases into the atmosphere to a greater or less extent. In the writer's opinion, all these things contributed to the destruction of the wall.

The main point is that any unprotected sheet steel or iron fabric which is exposed to the action of the atmosphere will corrode, and that in buildings where settlement, vibration, or expansion and contraction due to temperature are apt to open up cracks in the plaster coat, which will allow the atmosphere to act upon the fabric, the life of walls of this type will be limited to from 4 yrs. to 10 yrs., depending on the degree to which the atmosphere inside nad outside the building is made up of destructive gases other than the ever-present oxygen and moisture found in all localities. For interior walls and in walls not apt to be cracked from any cause the life should be 20 yrs. and upward.

Mr. Wagner believes that the character of the furring has much to do with cracking and consequent deterioration. Extracts from his discussion contain hints for overcoming this trouble:

We are inclined to believe that construction of the base for applying stucco is giving the most trouble.

The cracks which appear over the supports or furring strips allow the moisture to penetrate through these cracks and rust out the lath; particularly if the stucco has been improperly pushed through, leaving a large portion of the metal uncovered on the rear side. It has been proven in many cases that the trouble was due to this cause and not due to the use of metal lath. The addition of short fibre asbestos will greatly improve the stucco, and a wash with a thin solution of white cement will produce an evenly colored and attractive surface.

Mr. Lane calls attention to several points which are likely to cause trouble unless given attention:

First, make sure that the foundations have settled to their normal position before the stucco coat is applied. It will readily be appreciated that the slightest move in the foundation after the stucco coat has been applied and especially while it is new will rack the building sufficiently to rupture to a greater or less extent the mortar coat.

Second, see that the water line is sufficiently separated from the ground to eliminate capillary attraction.

One of our best stucco men advises the placing of the sheathing if any is used, on the inside instead of next to the lath. By this means an equal degree of warmth is secured and the only wood coming in contact with the metal lath would be the edge of the studding, which would not average more than 1¾" of wood to from 16" to 24" of lath surface, and this method eliminates any danger of possible defects from warping, contraction or expansion of unseasoned lumber.

There still enters into the consideration of the subject the question of the workmanship upon the stucco; whatever may be the base upon which it is laid, careful and intelligent workmanship is a necessity.

The mortar coat must be well forced through, or into that which provides the plaster key. Ten % (by weight) of lime putty is an essential in the mix and the best results can be secured by allowing the first and the second coat to stand where possible as long as 2 mos. or 3 mos. before the application of the finishing coat.

Mr. Coddington believes that stucco on metal lath should be back-plastered for dependable results, and writes in part:

No matter how good the mortar, or how well the plastering is done, if the base or ground is not right, failure sooner or later is inevitable.

The writer came to the conclusion many years ago that the open mesh type of lath over sheathing was wrong in principle, whether of wood or metal. What we mean by open mesh lath is a type in which the mortar, flowing through the meshes or openings between the lath, forms clinches or keys on the back of the lath, but does not completely enclose or embed the lath elements.

Our reason for condemning this construction is the practical impossibility of completely embedding the lath within the mortar and unless this condition is obtained, disintegration is only a matter of time.

Mr. Edwards has faith in stucco on metal lath when the work is carefully done. In his discussion, he states:

The fact that we are using small mesh metal fabric (not less than 24 ga.) in all our large silo and water tank structures is evidence that we are ourselves very confident of its desirability for such uses.

With this class of reinforcement care should be taken not to use any gypsum plaster. The plasterer should see that the mortar gets a good key behind the lath. My personal objection to metal lath construction as generally employed is that wood furring strips are so often used, also that there is no interlock afforded at sides and ends of sheets.

Many instances of very long life have been noted, which confirms the opinion of many that proper construction and workmanship are the key to permanency.

Mr. Reno cites an instance, as follows:

> We find from very careful inquiry that metal lath in stucco is practically everlasting, providing the stucco is applied in the proper manner. Recently the writer saw in Pittsburgh stucco 23 yrs. old being torn off, due to alterations. The lath used was 24-ga. unpainted steel. There was no sign of rusting, in fact the gauge has not been reduced in any way as far as we could detect with calipers.
>
> Under certain conditions expanded metal lath will give trouble, but it is generally due to the fact that it is not properly used. Our recommendations are that metal lath be not furred out to exceed ⅜″ from the sheathing. When used in this way the plasterer does not try to save on the mortar but shoves it through and it back-plasters itself.

Another instance of similar nature is taken from a letter from Mr. Powell:

> Some 18 mos. ago a stucco house at Joliet, Ill., was remodeled. The stucco in this case had been put on over painted lath about 12 yrs. previously. It was found in making repairs that the lath was in perfect condition. We have had any number of instances brought to our notice of metal lath which had been in place for 15 yrs. and 18 yrs. and the work is still perfect.
>
> It seems that the solution of the problem is the use of the painted or galvanized lath.

Mr. Murray, after a discussion of proper precautions to be observed, says:

> If the proper mixture is used, I am frank in stating that I conscientiously believe that metal lath covered with a cement plaster in stucco will last indefinitely. There are any number of structures throughout the country that are entirely satisfactory. As a matter of fact, the walls of our own shops here are 2-in. cement plaster. We recently had occasion to cut out a piece of wall which had been constructed about 5 yrs., and the metal was in just as good condition as the day it was put in the wall. The cement plaster used was a 1:2½ mix, with about 8% of lime added to make it work neatly, and the walls were waterproofed.

SPECIFICATIONS

The Am. Concrete Institute has for a number of years given much attention to perfecting stucco. Following is a summary of its specifications:

PREPARATION OF ORIGINAL SURFACE

The frame is to be rigidly constructed. Sheathing to be from 6″ to 8″ wide, laid diagonally and nailed with two nails at each stud. Sheathing to be covered with waterproof paper laid horizontally, paper to lap well at all joints.

Furring to be of metal crimped strips not less than ¼″ high, No. 18 ga. galvanized or equal. Strips to be not more than 16″ o. c. and over studs. Closer spacing to be used on curved surfaces so as to hold the lath ¼″ from the sheathing. Furring strips to be placed not less than 1½″ nor more than 4″ from all openings and provided at all vertical joints of the lath.

METAL LATH

Metal lath shall be woven wire, expanded or deformed sheet metal. It shall be galvanized and no cutting or punching shall be done after galvanizing except that necessary for erection.

The metal shall be of such shape that when in place plaster applied and forced through against the sheathing boards will completely embed the metal.

Lath shall be placed with its stiffest axis horizontal and fastened by galvanized staples not more than 8″ apart, which shall straddle the furring strips and reach to the inside of the sheathing. Each sheet shall lap the next one mesh or one row of deformations.

[*Editor's Note:* In order to make this summary complete, specifications for wood lath and masonry are included.]

WOOD LATH

Over sheathing paper shall be placed vertically 8″ o. c., No. 1 spruce, cedar or white pine laths, well nailed. There shall be applied over these horizontally the same quality laths, spaced ½″ apart, nailed with galvanized nails at each furring strip.

The lath shall be thoroughly wet with a hose, using sufficient force to drive the water back of the lath, and time shall elapse before applying the mortar sufficient for the lath to absorb the water.

Immediately after placing the first coat of mortar the surface shall be scratched and 1-in. mesh chicken wire stapled over the mortar with galvanized staples. The wire shall be lapped 1′ at corners.

BRICK, TILE AND CONCRETE

Old surfaces shall be thoroughly cleaned and joints raked out ½″. If the surface has been painted or cannot be cleaned, metal furring and lath shall be applied.

New surfaces shall have ample roughness to assure a good bond. Mortar joints shall be ⅜″ thick and raked ½″ deep. All surfaces shall be thoroughly saturated before applying stucco.

MATERIALS

Cement shall meet standard specifications. Fine aggregate shall be graded from fine to coarse and pass when dry a screen having ⅛-in. holes. It shall be clean and free from dust.

Hydrated lime is to be preferred, but when lump lime is used it shall be slaked in 2½ volumes of water and shall stand 1 wk. before using.

When quick lime slaked on the job is used, 35 lbs. of lump lime shall be allowed to 1 bbl. of cement. Hair or fiber shall be first quality cow hair or long cocoanut fiber, well combed.

Coloring matter if used shall be a mineral which is not affected by lime or cement. The water used must be clean and free from oil and alkali.

MIXING

The ingredients shall be thoroughly mixed dry until of even color. Slaked lime shall be mixed with water to the consistency of thin cream and added to the mix in that form. Dry hydrated lime is to be added to the batch before dry mixing.

All materials shall be accurately measured, all proportions are stated by volume. No more mortar shall be mixed than can be used within 1 hr. and no mortar is to be retempered.

Mixing by hand is to be done on a tight platform and materials turned until homogeneous. The mortar shall contain sufficient water to insure a proper bonding and a dense mortar free from voids.

SCRATCH COAT

The first coat shall be mixed 1 cement, 2½ aggregate and ¼ part dry hydrated lime. Sufficient hair is added to bind the mortar when applied to lath; 3 lbs. to 4 lbs. hair per bbl. of cement is about right. The scratch coat shall be pushed through the lath so as completely to fill the space between it and the sheathing and all voids around furring and laps.

When applied to masonry mortar shall be forced into all voids of the saturated surface. The minimum thickness of the scratch coat over the lath shall be ¼″.

Precautions must be taken to prevent rapid drying in hot weather and the surface shall be thoroughly scratched and roughened.

INTERMEDIATE COAT

The intermediate coat shall consist of 1 part Portland cement, 3 parts aggregate and ¼ part hydrated lime. This coat is applied as stiff as it can be worked to secure greater impermeability; it shall be applied over a thoroughly wet scratch coat as soon as the scratch coat is hard enough to work upon. The thickness shall not be greater than ⅜″ and it shall be well troweled into contact with the previous coat. This coat shall be properly scratched and protected. The intermediate coat may be omitted over masonry.

FINISH COAT

The finish coat shall be mixed with the same proportions as the intermediate coat. Colors when used are to be thoroughly mixed with the dry material. It is desirable to mix enough material dry for the entire job at once to secure uniform color.

The finish coat shall be applied to the wetted under coat as soon as practicable. It shall be not more than ¼″ thick over the intermediate coat nor more than ⅜″ thick over a scratch coat. It shall be pressed on hard but troweled no more than is necessary to secure an even surface.

SURFACE FINISH

Smooth Troweled—The finishing coat shall be troweled smooth with a metal trowel with as little rubbing as possible.

Stippled—The finishing coat shall be troweled smooth with a metal trowel with as little rubbing as possible and then shall be lightly patted with a brush of broom straw to give an even stippled surface.

Sand Floated—The finishing coat after being brought to a smooth, even surface shall be rubbed with a circular motion of a wood float, with the addition of a little sand to slightly roughen the surface. This floating shall be done when the mortar has partially set.

Sand Sprayed—After the finishing coat has been brought to an even surface it shall be sprayed by means of a wide, long fibre brush—a whiskbroom does very well—dipped into a creamy mixture of equal parts of cement and sand, mixed fresh every 30 min. and kept well stirred in the bucket by means of the whiskbroom or a paddle. This coating shall be thrown forcibly against the surface to be finished. This treatment shall be applied while the finishing coat is still moist and before it has attained its final set, i. e., within 3 hrs. to 5 hrs. To obtain lighter shades add hydrated lime of 5% to 15% of the volume of the cement.

Splatter-Dash or Rough-Cast — After the finishing coat has been brought to a smooth, even surface and before attaining final set, it shall be uniformly coated with a mixture of 1 part cement and 2 parts of sand thrown forcibly against it to produce a rough surface of uniform texture when viewed from a distance of 20′. Special care shall be taken to prevent the rapid drying out of this finish.

Pebble Dash—After the finishing coat has been brought to a smooth, even surface and before attaining initial set, clean, round pebbles or other material as selected, not smaller than ¼″, or larger than ¾″, shall be thrown forcibly against the mortar so as to embed themselves in the fresh mortar. They shall be distributed uniformly over the surface of the final coat and may be pushed back into the mortar with a clean wood trowel, but no rubbing of the surface shall be done after the pebbles are embedded.

Exposed Aggregates — The finishing coat shall be composed of an approved selected coarse sand, marble dust, granite dust, or other special material, in the proportions given for finishing coats and within 24 hrs. after being applied and troweled to an even surface, shall be scrubbed with a solution of 1 part hydro-chloric acid in 4 parts of water by volume. After the aggregate particles have been uniformly exposed by scrubbing, the wall shall be thoroughly washed down by spraying with a hose to remove all traces of the acid.

Mortar Colors—When it is required that any of the above finishes shall be made with colored mortar, not more than 6% of the weight of Portland cement shall be added to the mortar in the form of finely ground coloring matter.

A predetermined weight of color shall be added dry to each batch of dry fine aggregate before the cement is added. The color and fine aggregate shall be mixed together and the cement and lime mixed in. The whole shall then be thoroughly mixed dry by shoveling from one pile to another through a ¼-in. mesh wire screen until the entire batch is of uniform color. Water shall then be added to bring the mortar to a proper plastering consistency.

WATERPROOFING

When a special waterproofing compound is to be added to mortar for stucco work, it shall be added to all coats in strict accordance with the specifications of the manufacturer.

CURING

Whatever finish is given the final coat, it shall be so protected from rapid drying out that the mortar shall have at least 4 das. to cure before drying on the surface. The walls shall be frequently sprayed by means of a hose and in dry weather shall be protected by burlap or other suitable hangings which may be kept wet.

FURTHER DISCUSSION

Many readers of this magazine are undoubtedly in a position to offer more information as to their own experience with stucco on metal fabric. And more discussion will be welcome.

Aggregate Sizes to Be Kept In Stock

THE QUESTION BELOW, ON WHICH NUMEROUS DISCUSSIONS WERE PUBLISHED LAST MONTH, IS FURTHER DISCUSSED BY WILMER WALDO[1]

"What sizes of concrete aggregate should a dealer be prepared to supply? In a general way, what sizes are in greatest demand and how large stocks should be carried?"

BY MR. WALDO

The condition of the business here is very similar to that in New England described by Mr. Garrod.[2] The majority of gravel and crushed stone plants are not prosperous as commercial supply propositions. Probably the best equipped plants are those maintained by large contracting companies which have found it impossible or inconvenient to depend on plants operating commercially. The contractors' plants as a rule sell only their overs which at times run into large orders but they frequently cannot be relied upon. Many plants have been abandoned by concerns in the contracting business and sold at a low figure to someone entering the supply business. Still others are a crude development of a gravel-pit proposition originally merely furnishing pit-run gravel for road use.

Most of the plants are inadequately financed, the exceptions being those which have gone into the business on the basis of large initial orders which have soon paid in the original capital invested. Where the plants are poorly financed they show the results of imperfect conception on the part of the promoters who have not diligently studied the relationship between gross and net income. It seems at times to take very little capital to get into the businss, but it always takes a great deal deal to produce and make deliveries with any businesslike precision; consequently, there are always starving propositions ready to sell at any figure which will produce some temporary return. The prices at which these sales are made indicate clearly that only the tangible or immediate costs of production, that is, the cash disbursements necessary to deliver the particular shipment, are taken into consideration in fixing the price. The deliveries of such a concern are nearly always unreliable and in the end expensive.

I think I am not mistaken in saying that even the successes are of temporary nature such as a result of a clean-up on some big delivery where circumstances favored quick turn-overs and eliminated long-suffering financing. Usually an inadequately financed concern and one under-equipped physically can stay in business long enough to break prices for a while. During this time the business is not prospering but it is creating an awkward situation for a reliable competing plant carrying a proper overhead charge.

I do not know whether capital looks upon the business here as low grade and not considerable or solid enough to justify its interest or whether it is a fact that capital has not been sufficiently sought or properly approached by reliable people. At any rate, there have been innumerable failures due both to under-financing of good propositions and bad management of fairly well financed concerns.

It is my personal belief that the business must be financed far beyond any previous conception to make it pay. It has appeared from the outside to be easy money to many who have since gone in only to find that it requires experience and close application to get away with any creditable showing. This misapprehension which makes the prospect attractive to a thoughtless class of operators seems to be the very thing which causes capital to look askance at the idea of financing such a proposal; they seem not to regard it as a legitimate business proposition but rather as a venture, notwithstanding that the product of the business is the basis of nearly all building and constructing.

In making these remarks I am referring to local conditions and one can hardly blame capitalists and bankers for unconsciously classifying the business with the jitneys in view of the numerous failures, some of them immediately after the money has been spent and before the output of the product has fairly begun. There is generally some new adventurer ready to go in where some one else has failed, always having in mind the volume of the outturn rather than the financial return. The result is that many new plants are constantly being installed with incomplete and inadequate equipment, while others no more unsatisfactory are being abandoned.

The business is comparatively new here and it must, I presume, go through all the agony of a new industry which has an attractive though elusive profit. Our whole coast country is studded with monuments marking failures in the rice business during the period preceding its commercial stability, when many enterprising but inexperienced farmers were the victims, first, of their own enthusiasm and, later, of unscrupulous salesmen of both land and machinery. It has been somewhat similar in the gravel and crushed stone business and will continue to be for some time unless the financial strength and the efficiency of some company can overcome all the handicaps of curb competition and the results of too many concerns located within shipping radius of the same market.

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[1] Contractor, Houston, Tex.

[2] CONCRETE, Sept., 1915, p. 117

This condition prevails around each good market. The freight rates usually prevent a member of one group from breaking into another market. Competition may seem very natural and is to be encountered anywhere, and the situation would not be bad if there were a steady demand. There is not, however, and this indicates that the market is not as yet a great one. When there is a demand it is a good one and it frequently calls for more than any one can supply within the time allowed. Under the circumstances an elastic plant which can carry a large payroll and expense during a dull period of, say, three months, would be able to create a large storage which would satisfy any demand immediately. On the other hand with such large storage capacity the plant could be shut down for any convenient period during repairs or labor troubles. Such a plant requires capital and plenty of it. It also needs close management and good salesmanship. It can, however, I believe, always sell at a profit because it can eliminate doubt as to deliveries which is worth several cents per yd. to any contractor and anyone who had had to wait knows it.

Concrete Elevator Withstands Galveston Storm

The 48-tank concrete grain elevator owned by the S. P. R. R. at Galveston stands on a slip within a short distance of the sea wall.

The grain tanks are 90′ high and the concrete working house is 150′ above the ground.

This structure was erected by James Stewart & Co., Inc.,[1] using Alpha cement.[2] The height of the water was 10′ above the previous high water mark, but the only damage was to some of the upper windows, which were blown in by the wind.

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[1] Chicago

[2] Alpha Portland Cement Co., Easton, Pa.

Correspondence: A Department in Which the *Reader* Becomes the *Writer* □

This is your department. It is informal. Use it. This is the place for letters which have either inspiration or information for the "other fellow." It is well to remember that you are usually in his position. If you are to get the good out of these columns, why not help to make them good? Write about your work. Help the Other "other fellow." □ □ □

Supplemental to "Field Examination of Concrete Sands"

—A LETTER FROM CARL H. FULLER[1]

Since writing the discussion of the Field Examination of Concrete Sands[2], the editor asks why I should be so emphatically in favor of sharpness in sand used for concrete and if it is not true that round grains produce a denser mixture than sharp angular grains. My reasons are derived from (a) experience, (b) custom, and (c) observation. That round grains or aggregate will pack closer is admitted, but that such will produce better concrete is questionable, as I think will be demonstrated by what follows.

The experience came while a boy, before I had learned that the terms surveyor and engineer were not necessarily synonymous, and with it came the knowledge of vast differences in clean sand, ranging all the way from the crystalline, angular grain, to the finer, globular grain, known as quicksand. In those days I lived in the heart of the Alleghenys, where the roads very largely followed stream lines and as bridges were few, fords were correspondingly numerous. These streams carry large quantities of sand and frequently the best fords were those having a sandy bottom. When the sand was sharp and angular, the crossing was invariably a safe one; conversely, if fine and globular, it was looked on with suspicion, being especially dangerous immediately after a rain.

One pecularity of wet quicksand is its ability to sustain a very considerable load at times, while on other occasions the same load will sink into it until entirely submerged. The degree of saturation is responsible for this condition, the water forming a thin film, entirely enveloping the tiny globular grains and causing them to separate from one another so that they move readily without much friction from under any load imposed, and close in over the object as it settles. The finer the grain, the more quickly such action develops. Quicksand, when in this saturated state, may be settled by giving it a sudden, sharp jar, and mountaineers, accustomed to using such fords, recognize this fact by striking the surface of the water quite smartly, several times, with the flat side of a board before venturing into the ford.

The sharp, angular grain has none of these properties and when confined at the bottom and sides, may be counted on with perfect safety to sustain the heaviest buildings, notwithstanding the Biblical quotation to the contrary.

Considering the second reason, that of custom, the writer believes that, lacking the opportunity to make laboratory tests, it is safe to follow the precepts and standards established by men accustomed to handling large and important work strictly according to specifications. That there has been a very noticeable lowering of standards in connection with concrete sands the writer believes has been largely the result of greed and ignorance. Unfortunately, in many places, it has been extremely difficult to obtain satisfactory sand at a reasonable price; hence the substitution. On the other hand, the development of the concrete industry has been very rapid and the simplicity of many of its operations has attracted a large number to its manufacture who, lacking the technical education, have failed to appreciate the difference in sands, or who perhaps did not care so long as they could dispose of their product. It is to be deplored, if such influences are to have a reactive effect on the manufacture of concrete products.

Under the head of observation,

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[2] Infor. and Cons. Dept., Aug., 1915, p. 73

[1] Indianapolis, Ind.

can be cited many minor details to support the preference for the angular grain which we know can be relied on. In the re-crushing of old concrete, using a jaw crusher, I have noticed that smooth gravel stones were frequently detached from the mass, leaving a smooth, circular cavity; where the mixture was lean, the cement and sand would pulverize, giving when screened, practically clean gravel. True, in very rich mixtures, large quantities of gravel stones would be split, but when this occurs the sand and cement are not so readily disintegrated, and come away in solid lumps, showing the cement to be as strong as the stone it enclosed, or even stronger. If the old aggregate happened to be crushed stone, the stone would more frequently be broken and unless the original mixture was quite lean, the individual stones were seldom free from cement. The relative strength of the stone and the cement materially affects the results obtained from such re-crushing operations, it being evident that the irregular, rough surface of crushed rock gives a better mechanical bond for the cement than the smoother surface of the gravel.

To illustrate better the point it is desired to make, construct a dry rubble wall, using roughly squared stones having faces varying from 1″ to 2″. Such a wall, if laid up carefully, may be built to a considerable height in proportion to its thickness, with faces practically plumb, and will sustain a considerable load. Substituting gravel stones of about the same size, their limitations are quickly apparent nor will such a wall sustain anywhere near the load of the other, owing to the lack of mechanical bond. If we attempt to construct our miniature wall of polished glass marbles, we find that we are limited to a triangular cross-section which will hardly sustain its own weight unless the bottom rows are restrained from movement.

Now make your rubble wall into a concrete wall by filling the interstices with sand and cement in the usual proportions. When set sufficiently, this wall will carry a considerably heavier load than before, being approximately equal to that which a similar cross-section of the same solid stone will support and which may be greater than the cement alone would be good for, depending on the relative strength of the stone. Make your gravel wall into a concrete wall, using the gravel for the aggregate and it will develop a strength somewhat greater than the cement alone but not so great proportionately as a cube of the same gravel will develop. Now use your glass marbles for the aggregate in constructing your wall and it will fail under a considerably smaller load than either the cement or the marbles alone will sustain when worked into a solid equivalent section, owing to the cement splitting away from the glass.

The point is, not that gravel is inferior to crushed rock of equal hardness for concrete, but that somewhere in the transition from the irregularly shaped rough stone which has a mechanical bond of its own, to the uniform sized, smooth-faced spherical aggregate having no (mechanical) bond, there is a point at which a sudden drop in strength will occur.

I wish that some one who has the laboratory facilities would make up three lines of cubical samples of different proportions, using in one crushed rock, in the second gravel and in the third glass marbles for aggregate, and when set for 30 das. crush in a testing machine. Then let him furnish the readers of this paper the comparative results in figures and with illustrations.

But what has this to do with sand? Simply that sand is smaller particles of stone and in these experiments the granular sand was represented by the crushed rock, the intermediate sands by the gravel and the quicksand by marbles, in order to visualize their relative properties.

Continue our experiment further, using sand itself. Take two shallow cigar boxes of the same size and remove the bottoms. Place on a level surface and fill, one with sharp sand and the other with quicksand, striking the tops level with a straightedge. Place carefully in the center of each a cubical or cylindrical weight of about 1 lb., a piece sawn from the end of a 1½-in. shafting being the best for the purpose. The weight applied to the granular sand will settle slightly and stop, while the weight on the quicksand will rise up in a slight ridge around it as the weight settles, showing that some of the particles have been displaced. Now lift the cigar box forms, being careful not to disturb the sand any more than is necessary, and note the difference in the area covered by the two sands, that of the quicksand being the greater, showing that it lacks much of the bonding property of the other. If the table now be jarred repeatedly, the weight on the quicksand will topple over or settle first, providing the experiment has been conducted with due care.

Again take two cigar boxes, having tight bottoms and insert through the side of each, near the bottom, a short length of glass tubing such as chemists use and connect by means of rubber tubing with a low pressure water supply. Fill the boxes, one with the sharp sand and the other with quicksand, placing the weights as before. Turn on the water and allow the boxes to overflow, maintaining light equal pressures of water. In the box containing the granular sand nothing will happen other than possibly a slight settlement of the weight, when it will stop and rest solid. In the other box the sand will apparently swell and overflow with the water, while the weight will continue to settle as long as the water has an opportunity to percolate under it.

These experiments, though rather crude, demonstrate that the smooth spherical quicksand, like the marbles, has no bonding properties, while the granular sands, like the crushed rock, have this property quite well developed. Until it can be proven that mechanical bond in the aggregate is of no consequence and that highly polished glass marbles will make as good concrete as crushed rock of the same size and strength, it would appear a matter of wisdom to adhere as far as possible to the use of the granular sands, it being impossible without careful laboratory tests to determine the dividing line, for like the man at the ford we know the one to be safe while the other should be looked on with suspicion.

According to the U. S. Geological Survey, crushed stone, which is the largest product common to more than one kind of stone, decreased in value from $31,677,871 in 1913 to $30,161,766 in 1914, a loss of $1,516,105 or near 5 per cent. The value in 1914, however, was greater by $1,569,230, or about 5½ per cent, than that of 1912. Granite and sandstone in 1914 made small gains in value, but trap rock and limestone each decreased.

Reinforced concrete construction permits a window area as high as 80%. The wall space can be restricted to the columns. That this saves bills for artificial lighting is self-evident. In addition, it increases the efficiency of workers and improves their disposition. More sunshine in the factory means more "sunshiny" people who are easier to manage and who do better work than grouches. — *Knickerbocker Komments.*

Organizations

American Concrete Institute, Charles L. Fish, Secretary, Harrison Building, Philadelphia, Pa.

American Concrete Pipe Association, Secretary, E. S. Hanson, 538 S. Clark St., Chicago.

American Highway Association, I. S. Pennybacker, Jr., Executive Secretary; Colorado Bldg., Washington, D. C.

American Road Builders' Association, Secretary, E. L. Powers, 150 Nassau St., N. Y. C.

Association of American Portland Cement Manufacturers, Percy H. Wilson, Secretary, Bellevue Court Building, Philadelphia, Pa.

Cement Products Exhibition Co., 208 S. LaSalle St., Chicago, Ill.; Robt. F. Hall, Secy., Chicago Cement Show, Coliseum and First Infantry Armory, Feb. 12-19, 1916.

Iowa Association of Cement Users, Secretary, H. H. Dean, Glenwood, Ia.

Mid West Cement Users' Association, Secy.-Treas., Frank Whipperman, Omaha, Neb.

Second National Conference on Concrete Road Building, J. P. Beck, Sec'y, 208 So. LaSalle St., Chicago. Chicago, Feb. 15-18, 1916.

Committees for Roads Conference

Sub-committees which are expected to submit reports at the Second National Conference on Concrete Road Building to be held in Chicago, Feb. 15-18, 1916, are announced by W. F. M. Goss, chairman and J. P. Beck, secretary of the Conference. Every man has previously accepted his assignment and work on reports is under way. The committees are:

1. Drainage and Preparation of Subgrade:

Chairman, Hector J. Hughes, Chairman School of Engr., Harvard University and Massachusetts Inst. of Tech., Cambridge, Mass.; Clinton Cowen, State Highway Commr., Columbus, Ohio; George W. Cooley, State Engr., Minn. State Highway Comm., St. Paul, Minn.; George A. Quinlan, County Supt. of Highways, Chicago; Edward T. Beck, Edward T. Beck & Co., Contractors, Cuba, N. Y.

2. Economical Widths of Pavement and Shoulders:

Chairman, J. J. Cox, Instructor in Civil Engrg., University of Mich., Ann Arbor, Mich.; Wm. W. Marr, Chf. State Highway Engr., Springfield, Ill.; Wm. A. Stinchcomb, County Surveyor, Cuyahoga County, Cleveland, Ohio; A. J. Rockwood, Cons. Engr. and Contr., Rochester, N. Y.

3. Problems of Design, Thickness, Crown and Grade:

Chairman, Ira O. Baker, Prof. of Civil Engrg., University of Illinois, Urbana, Ill.; Thos. H. MacDonald, Highway Engr., Iowa State Highway Comm., Ames, Ia.; H. L. Bowlby, Executive Officer, Pacific Highway Assn., Portland, Ore.; Eugene W. Stern, Chf. Engr. of Highways of Manhattan, N. Y. C.; R. C. Hunt, Contr., Washington Court House, Ohio.

4. Aggregates:

Chairman, D. A. Abrams, Instructor in Charge, Structural Materials Research Laboratory, Lewis Inst., Chicago; W. K. Hatt, Prof. of Civ. Engr., Prudue Univ., Lafayette, Ind.; Chas. F. Shoop, Asst. Prof. of Experimental Engrg., Univ. of Minn., Mineapolis, Minn.; H. S. Mattimore, Asst. to First Deputy Commr., In Charge of Physical Testing, New York State Highway Comm., Albany, N. Y.; A. S. Rea, Engr. of Tests, Ohio State Highway Dept., Columbus, Ohio.

5. Handling and Hauling Materials and Water Supply:

Chairman, T. R. Agg, Prof. in Charge of Highway Engrg., Ia. State Coll., Ames, Ia.; H. G. Shirley, Chf. Engr., Md. State Roads Comm., Baltimore, Md.; Edw. N. Hines, Chmn., Board of County Road Commrs., Wayne Co., Detroit, Mich.; R. N. Waid, Natl. Road Engr., Ohio State Highway Dept., Columbus, Ohio; E. H. Cowan, Vice-Pres., The Farrell Engrg. & Constn. Co., Contrs., Cleveland, Ohio.

6. Organization of Concreting Crew:

Chairman, H. P. Gillette, Editor-in-Chief, *Engineering and Contracting,* Chicago; E. I. Cantine, State Highway Engr., Ore. State Highway Comm., Salem, Ore.; Wm. F. McVaugh, County Engr., Madison Co., Anderson, Ind.; Walter Buehler, Civ. Engr., Smithville, Minn.; O. T. Dunlap, Dunlap-Dippold Co., Contrs., Edwardsville, Ill.

7. Proportions of Materials and Consistency of Concrete:

Chairman, W. S. Gearhart, Kan. State Engr., Manhattan, Kan.; A. N. Talbot, Prof. of Municipal and Sanitary Engrg., Univ. of Ill., Urbana, Ill.; W. M. Acheson, Div. Engr., N. Y. State Highway Comm., Buffalo, N. Y.; H. S. Van Scoyoc, Chief Engr., Toronto-Hamilton Highway Comm., East Toronto, Can.; F. L. Rice, F. L. Rice & Sons, Contrs., Shelby, Ohio.

8. Mixing and Placing Concrete:

Chairman, Ernest McCullough, Civ. Engr., Chicago; A. D. Williams, Chf. Engr., State Roads Comm. of W. Va., Morgantown, W. Va.; John Wilson, Civ. Engr., Duluth, Minn.; Ernest Ashton, Chem. Engr., Lehigh Portland Cement Co., Allentown, Pa.; G. E. Scott, Contr., Norwalk, Ohio.

9. Reinforcement:

Chairman, Richard L. Humphrey, Consult. Engr., Philadelphia, Pa.; Leonard S. Smith, Prof. in Chg. of Highway Engrg., Univ. of Wis., Madison, Wis.; J. S. McCullough, City Engr., Fond du Lac, Wis.; Richard L. Saunders, Deputy Highway Commr. of Conn., Hartford, Conn.; R. M. Hudson, Contr., Atlanta, Ga.

10. Joint Location and Construction:

Chairman, George A. Ricker, Former First Deputy Commr., N. Y. State Highway Comm., Albany, N. Y.; H. J. Kuelling, County Highway Commr., Milwaukee Co., Milwaukee, Wis.; Fred C. Smith, City Engr., Sioux City, Ia.; E. D. Boyer, Engr., The Atlas Portland Cement Co., N. Y. C.; Austin W. Summers, Contr., Buffalo, N. Y.

11. Expansion and Contraction:

Chairman, F. E. Turneaure, Dean, Coll. of Mechanics and Engrg., The Univ. of Wis., Madison, Wis.; Paul D. Sargent, Chf. Engr., State Highway Comm., Augusta, Me.; Gaylord C. Cummin, City Mgr., Jackson, Mich.; W. A. McIntyre, Chief Road Engr., Assn. of Am. Portland Cement Mfrs., Philadelphia, Pa.

12. Finishing and Curing:

Chairman, Charles Whiting Baker, Editor-in-Chief, *Engineering News,* N. Y. C.; W. A. McLean, Engr. of Highways, Dept. of Public Wks. of Ont., Toronto, Ont.; H. M. Sharp, Deputy State Highway Commr., State Highway Dept., Columbus, Ohio; Wm. M. Kinney, Inspect. Engr., Universal Portland Cement Co., Chicago; Howard W. Underwood, Field, Barker & Underwood, Contrs., Philadelphia, Pa.

13. Construction of Shoulders and Curbs:

Chairman, A. N. Johnson, Highway Engr., Bur. of Municipal Research, N. Y. C.; A. W. Dean, Chf. Engr., Mass. Highway Comm., Boston, Mass.; A. B. Fletcher, Highway Engr., Cal. Highway Comm., Sacramento, Cal.; Charles E. Russell, County Supt. of Highways, Lake Co., Waukegan, Ill.; Edward M. Laing, Pres., Edward M. Laing Co., Contrs., Highland Park, Ill.

14. Methods and Cost of Maintenance:

Chairman, A. H. Hinkle, Deputy Highway Commr., Ohio State Highway Dept., Columbus, Ohio; L. C. Herrick, County Engr., Norwalk, Huron Co., Ohio; John W. Mueller, Civ. Engr., New Castle, Ind.; Maurice Hoeffken, Hoeffken Bros. Supply and Constn. Co., Contrs., Belleville, Ill.

15. Form of Specifications:

Chairman, A. R. Hirst, State Highway Engr., Wis. Highway Comm., Madison, Wis.; F. F. Rogers, State Highway Commr., Mich. State Highway Dept., Lansing, Mich.; C. B. Breed, Consult. Engr., Boston, Mass.; F. P. Wilson, City Engr., Mason City, Ia.; R. D. Baker, The R. D. Baker Co., Contrs., Detroit.

16. Cost of Construction:

Chairman, C. J. Bennett, State Highway Commr. of Conn., Hartford, Conn.; H. Eltinge Breed, First Deputy Commr., N. Y. State Highway Comm., Albany, N. Y.; E. J. Mehren, Editor-in-Chief, *Engineering Record,* N. Y. C.; C. U. Boley, City Engr., Sheboygan, Wis.; Frank A. Windes, Windes & Marsh, Contrs., Winnetka, Ill.

17. Estimating and Inspection Problems:

Chairman, A. Marston, Dean and Director, Div. of Engrg., Ia. State Coll., Ames, Ia.; John H. Mullen, Deputy State Engr., Minn. State Highway Comm., St. Paul, Minn.; K. H. Talbot, Div. Engr., Universal Portland Cement Co., Pittsburgh, Pa.; H. A. Johnston, Contr., Kalamazoo, Mich.

Standard Rating for Batch Mixers

The lack of any standard method of rating batch mixers led the National Assn. of Mixer Mfrs. at its August meeting to adopt a resolution providing for uniform rating. The announcement of the association, by Sec'y H. E. Smith is in part:

> Some mixer manufacturers rate their machines by their capacity in mixed concrete, while other manufacturers rate them by their capacity in loose unmixed material. It is a well known fact that a mixer having a batch capacity of 8 to 9 cu. ft. of unmixed sand, stone and cement will hold only about 6 cu. ft. of mixed concrete per batch. For this reason the term three-, four-, or nine-foot mixer has never had any real, definite significance.
>
> The resolution adopted by the association provides that the members of the association in future catalogs and circulars shall specify the capacity of their mixers as "size of wet, mixed batch," and not otherwise. The resolution further provides that the dry unmixed capacity of a mixer may be approximated as one and one-half times the wet mixed batch, assuming the use of cement, sand and $1\frac{1}{2}$-in. crushed stone, with $1\frac{3}{4}$ gals. of water per cu. ft. of mixed concrete. The members of the association further agreed not to use the dry batch rating in their correspondence, advertising, etc., unless the standard wet batch rating is used also and with equal prominence.

When grouting the joints of sewer pipe the grout should be poured from one side until it flows around and begins to fill the opposite side, when the pouring should be finished from that side. This causes a wave action that insures close filling at the bottom of the joint.

New Equipment, Methods and Materials:

New Tools with Which the Industry Works

***This magazine will not publish "reading notices," so-called, for the benefit of advertisers. These pages are edited for the Reader, as are all other pages in "Concrete." Manufacturers are constantly producing new and better methods and developing old methods, materials and machines. The progress of the concrete field is measured by the development of its tools. All developments along these lines are of real interest and importance to men who want to improve the quality of their work, decrease its cost, increase its quantity. This department is for just that kind of Editorial material. We, therefore, welcome detailed announcements which will be of practical value to Readers. Under no circumstances will this magazine publish any announcement simply because an advertiser asks it, nor refuse publication because a non-advertiser asks it. Material must carry information of real consequence to the reader. All material will be edited on that basis regardless of the source from which it comes.*—The Editors.**

Stone Facing Aggregates in Colors

The increased architectural uses of manufactured stone which must ultimately follow a more general appreciation of and development in special aggregates for variety in color and texture in the finished products, has frequently been mentioned in this magazine. Many producers of special facing and body aggregates have not met with prompt success. Some failures to establish available supplies of such materials in the concrete field have been due to the slowness of products manufacturers generally in seeing the possibilities in their use or to their feeling of inability to cope with the educational campaign necessary to introduce the higher-priced products on the market. Still other failures to build up a business in supplying quarry waste to products manufacturers have undoubtedly been due to a failure to understand the needs of the products manufacturer. He must buy in small quantities at the outset and experiment in making new products and must then try out his new products on architects. He might require special materials screened to definite size or he might require graded material.

Some new offerings to products manufacturers are being made by Julius Ruoff,[1] and there is better hope for the success of his idea to supply prepared facing materials because he has had more than a score of years in concrete stone manufacture. Much of his inspiration for a better development of concrete stone for ornamental work and building trim comes from his long study of the methods of German manufacturers. Mr. Ruoff uses coloring matter rarely but depends chiefly for his results on crushed stone of various colors, well graded, used either as a facing or throughout the body of the product and finished by the use of acid 24 hrs. or so after manufacture—either scrubbing or dipping in a tank and by careful curing. Much of his work is rubbed with carborundum, first coarse and then fine. He emphasizes the importance of using a facing of 1 part well seasoned cement and 3 parts to 4 parts of sharp, crushed stone, graded from fines to ¼-in.—the largest size and the grading both being varied with the texture sought. He vigorously decries the use of fine sand facing, requiring a rich mixture, very apt to craze, and he emphasizes the importance of thorough mixing. Mr. Ruoff offers to other manufacturers special graded stone aggregates for a variety of work.

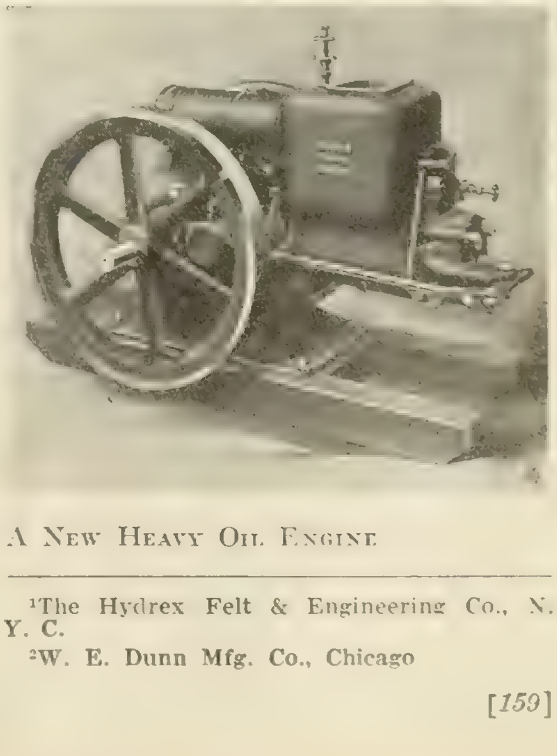
A New Expansion Joint Filler

It is hardly necessary to emphasize the superiority of a prepared strip of waterproof, elastic material for pavement joint filler, over the poured joints of material which must be heated. The prepared joint is in very general use. The Hydrex expansion joint cushion strip[1] is on the market. It is in lengths of 5′ and in thicknesses as required.

A New Heavy Oil Engine

The feature connected with the Dunn heavy oil engine[2] is the absence of electrical ignition and carburetor. It neither uses nor requires batteries, magneto, spark plugs, mixing valve, timer, switches, igniter, spark coil, hot ball, hot tube, spray nozzle, nor any other delicate mechanism or parts.

By means of a patented fuel cup, or combustion chamber, combustion



A New Heavy Oil Engine

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[1] Ruoff Const. Co., Philadelphia

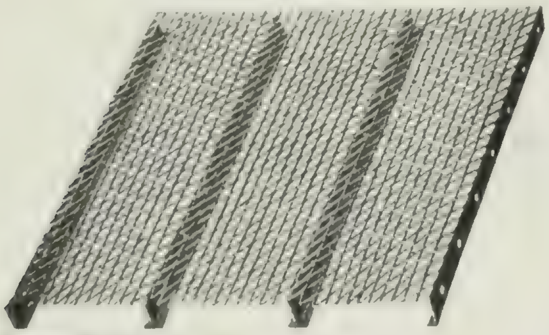
[2] Carborundum Co., Niagara Falls, N. Y.

[1] The Hydrex Felt & Engineering Co., N. Y. C.

[2] W. E. Dunn Mfg. Co., Chicago

is entirely by air compression. It is built to burn the heaviest, cheapest oils produced, fuel oils, residuum oils and similar fuels that can be bought for 4 cts. to 6 cts. a gal. being used. In round figures, said to be conservative, a Dunn engine developing 6 h. p. under full load, can be operated at a fuel cost of 24 cts. per 10-hr. da.

While no attempt has been made to promote its sale until the builders had tested it out thoroughly, they report that a number of these engines have been in service for upwards of two years and, in general, have more than fulfilled the expectations of both the manufacturers and the users.


New Metal Lath

A New Type of Metal Lath

On a great many classes of work a special form of metal lath combining a furring or reinforcing with the mesh is found to be of advantage. Such a material is particularly adapted for use in solid plaster partitions and for lathing suspended ceilings. A combined lath and reinforcing is also of material advantage as a form and reinforcing in the construction of concrete roofs and floors. A new material,[1] shown in the illustration, has just been put on the market to meet this demand for a material of this kind.

The reinforcing or furring members of Chanelath consist of T-shaped ribs spaced 4″ apart and connected by a small mesh lath. The ribs are solid and the mesh extends in an unbroken surface across the entire sheet. This is to give a perfect key when the lath is to be covered with plaster.

The T-shaped ribs are efficient when the Chanelath is used as a reinforcing for concrete because of their shape. This new product is furnished in sheets of any width that is a multiple of 4″ up to and including 4′. The lengths are 6′, 8′, 9′, 10′ and 12′.

Road Reinforcing Mesh

There is now being offered Kahn road reinforcing mesh,[2] a diamond mesh in two sizes, 6″ x 12″ and 6″ x 16″, with steel areas per ft. of width in various quantities—for the 6-in. x 12-in. mesh, .053, .066, .074 and .079 sq. in. in transverse area and .027, .033, .037 and .0395 sq. in. in longitudinal area and the 6-in. x 16-in. mesh, .056, .069, .076 and .082 sq. in. transverse and .021, .026, .029 and .031 sq. in. longitudinally. It is offered as meeting the requirements for concrete road reinforcing in being in rigid sheets, in widths from 3½′ to 7′, in various stock lengths.

A New Facing Material in Many Colors

Microlithic facing[1] and plaster finish will interest concrete products manufacturers and other concrete workers, because it has most interesting color possibilities in variety not available in the facing materials generally known.

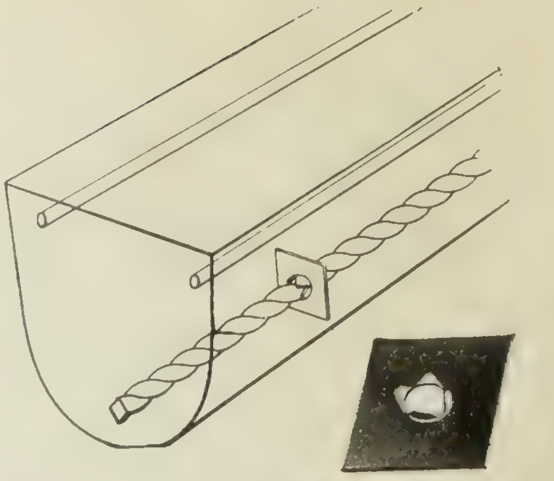
The producers have a large tract of land with mica deposits. Attention was attracted to other formations on the land, including, the producers say, "15 different, distinct natural colors of a granitized formation all heavily impregnated with small mica flakes."

The producers suggest the use of the material with cement for plaster or stucco coatings, to be washed down with acid and as a facing material in a mixture of about 2 cement to 3 of the flakes. It is also suggested for wet process work that the Zagelmeyer[2] method be used. This consists of gluing the facing on the face plate; then when the glue has set, painting over with grout which is backed up with concrete. The material comes not only in great variety of color but in different gradings—that for the glued facing having all dust removed.

The samples of concrete with microlithic facing received by this magazine show interesting possibilities for the products manufacturer.

Simple Fence Post Rod Spacers

The rod spacers[3] shown in the accompanying illustration consist of small squares of sheet metal with center perforations, not punched out, but stock pushed aside in four or more pointed spurs which stand at right angles to the face of spacer, forming a shoulder brace which does not allow spacer to lie flat upon the rod, but holding it at right angles to the rod.


The Spacer and Its Use

These are designed especially for use in reinforcing fence posts, but are serviceable in placing reinforcement rods for other work. A thousand spacers for ¼-in. rods to be held ½″ from form weigh only about 6 lbs.

For the U-shaped line molds for which they were originally designed they are used upon the lower rods only or those in the rounding side of form, it being intended that the rods in flat side or face of post be placed by hand, where they can be conveniently located in correct positions.

With a standard 3-in. x 5-in. line post mold, the single rod can consist of a ¼-in. twisted square or $\frac{5}{16}$-in. round, spacers placed every 2′ or 3′ will be found ample, or three spacers per rod for the average line post. In the round back mold, only two possible points of the spacers come in contact with the form, and examination has failed to reveal a single sign of their showing on the surface of the finished post. Designed for flat forms, the spacers may be in star or other shape to suit the work.

A New System of Unit Construction

This magazine has described a number of ingenious plans for the manufacture of concrete building units that were intended to combine low manufacturing cost with permanent and fire-resisting construction.

A unit of this kind holds many advantages over work that is built in forms, provided it is sufficiently flexible to adapt it to all uses, presents a good appearance and can compete in cost with other construction materials.

The system which is the subject of this article has been worked out in great detail by Ralph Z. Hopkins, C. E.[1]

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[1] Northwestern Expanded Metal Co., Chicago

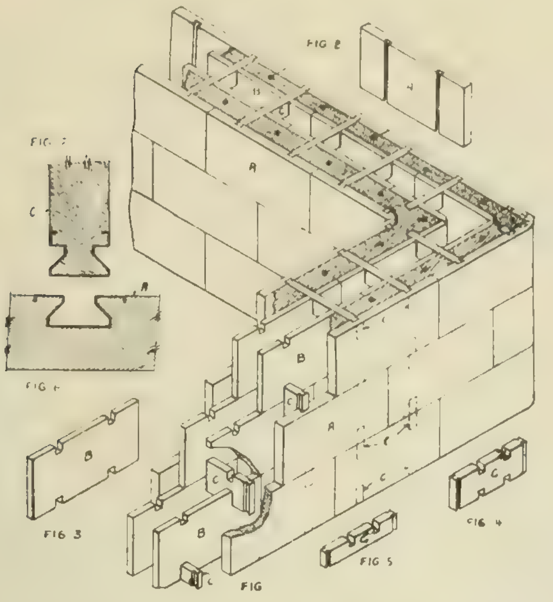
[2] Trussed Concrete Steel Co., Youngstown, Ohio

[1] The Texas Mica Co., Van Horn, Tex.

[2] Zagelmayer Cast Stone Block Machy. Co., Bay City, Mich.

[3] D. & A. Post Mold Co., Three Rivers, Mich.

[1] Detroit



Details of a Proposed System of Construction with Concrete Units

It has not yet been given a trial under actual manufacturing conditions, but a series of trials with full size units made with experimental equipment indicates that satisfactory results may be expected.

A typical wall section is shown in Fig. 1. This wall is made up of three distinct units.

Outer Unit A, Fig. 2, is a concrete slab, plain or reinforced as desired, 8″ x 16″ x 1¼″. Units A form the inside and the outside surface of the wall and are held in place by tie units which fit into the dovetailed grooves running vertically across the inner face of unit A.

Inner unit B, Fig. 3, is the same size as the outer unit but is only ¾″ thick. The notches cast into its upper and its lower edge fit into similar notches in the tie unit and are held in place by them. These units serve to form vertical planes which divide the wall into parallel spaces. Fig. 1 shows a wall divided into three spaces, the center space being left as an air space while the outer and the inner spaces are filled with concrete to give the wall greater strength.

Tie unit C, Fig. 4, is 1″ thick and one-half the height of the inner and the outer units. Its length and the number of notches in its upper and its lower edge are determined by the width of the wall and the number of spaces required.

Fig. 5 is the tie unit used in starting or finishing the wall.

The distinguishing feature of the construction is the method of locking the units together; a very strong and close-fitting joint is secured by reinforcing the tongue and groove with a sheet metal facing. Full-size sections are shown in Figs. 6 and 7.

Manufacture.—All units are designed to be cast in steel gang molds. These molds are to be built of cold rolled steel bars and sheet metal stampings and require little machine work. The concrete will be poured at a sloppy consistency and the molds, on cars, jarred to insure perfect filling. The cars with the filled molds will be run into the steam rooms for from 12 hrs. to 20 hrs. of curing.

The method of providing the metal faced dovetail is of particular interest. Thin sheet metal is formed by rolls into the exact shape for both tongue and groove. To the forms are riveted cold rolled bars, the exact size of the inside of the sheet metal strip. Before filling the forms the strips are placed in position over the supporting bars and must therefore be in exact position and size in the finished unit.

The notches in units B and C are provided by bars of proper section running transversely of the gang molds, the division plates being properly notched to receive them.

Surface Finish.—So exact are the units made by this process expected to be that very little mortar will be used. When an attractive finish is desired, it is proposed in order to expose the aggregate to grind the face of the units with horizontal grinders similar to those used for finishing marble and similar stone. By carefully selecting aggregate a very attractive unit should be secured. It is also proposed to provide a roughened surface to which plaster or stucco can be applied.

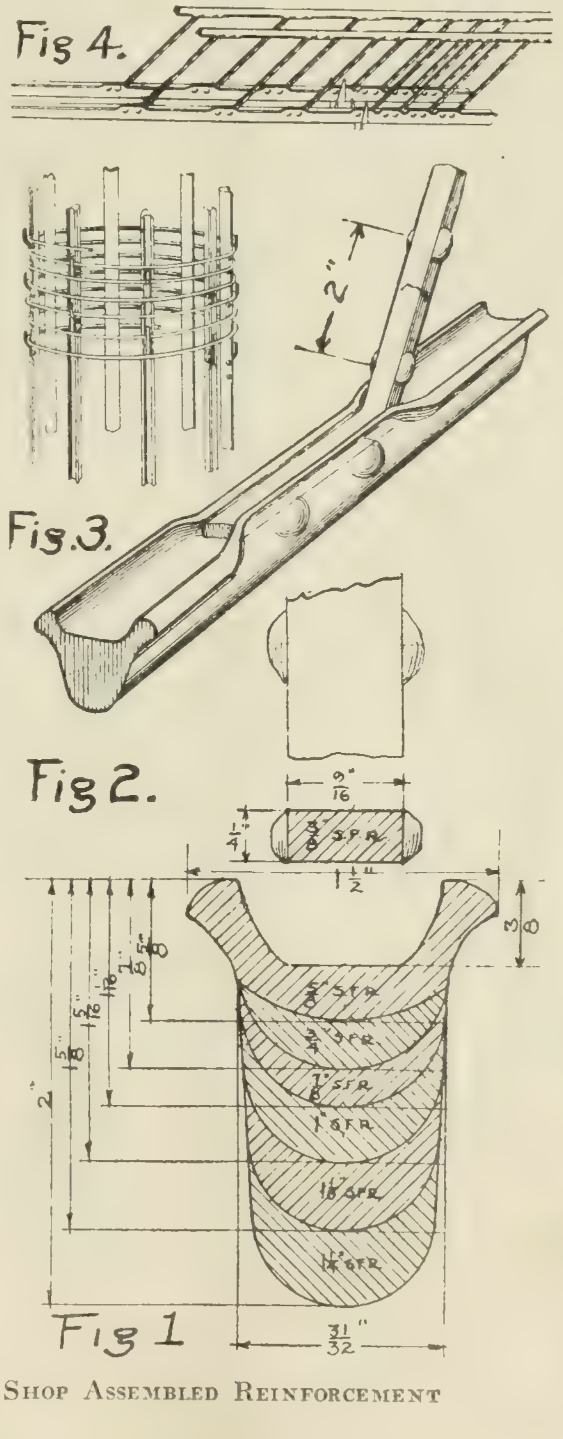
The inner walls of the building can be plastered direct as the four pieces of sheet metal used at the ties will doubtless prevent transmission of sufficient cold to cause condensation.

Shop Assembled Reinforcement

Shop assembled reinforcement has been used to a considerable extent but an entirely rigid method of securing the auxiliary bars to the main bars which is at the same time adapted to all requirements and low in cost has not been easily worked out.

The essential features of a new system[1] are well shown in the illustrations. Fig. 1 shows a section of the standard bars which are rolled in 6 sizes as shown. The auxiliary bars used are rolled with knobs spaced 2″ apart. Fig. 2 shows an assembled detail. The ribs of the standard bar are compressed over the auxilary bars forming a joint which tests have shown to be stronger than the auxiliary bar.

Fig. 3 shows a column reinforcing unit assembled and at Fig. 4 is shown half of an assembled beam unit.

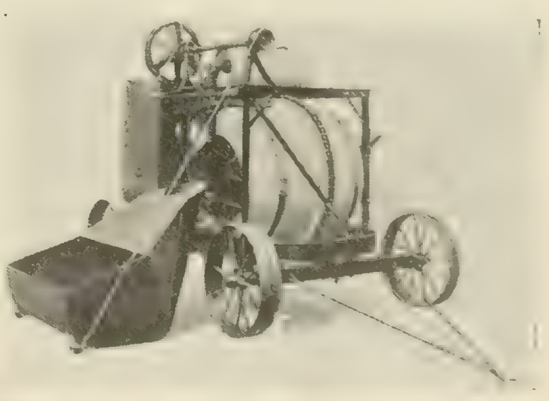


Shop Assembled Reinforcement

Rex Low Charging Mixer

The small concrete mixer has become one of the most essential pieces of equipment, not only to the contractor who specializes in the smaller work, but as an easily moved handy unit it is in great favor on the larger operations.

The illustration shows the Rex[2] 10 equipped with loader and water tank



The Rex 10 With Side Loaders

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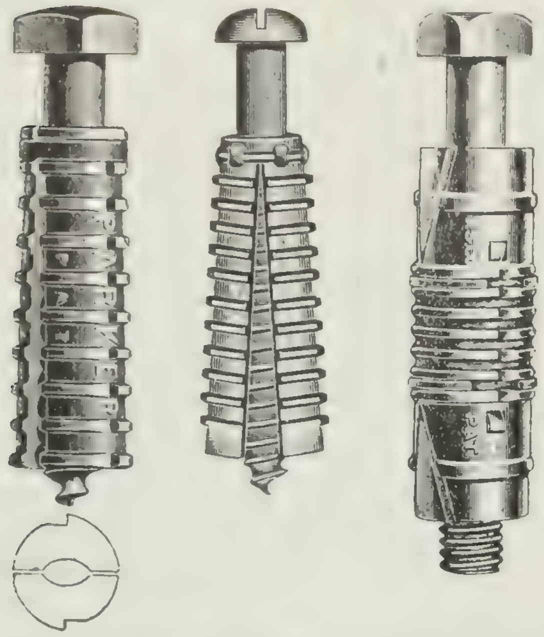
[1] Invented by Armen Tashjian, Consult. Engr., Cleveland, and marketed by the Shop Fabricated Reinforcement Co., Cleveland

[2] Chain Belt Co., Milwaukee

and driven by a gasoline engine. Special emphasis is laid on the low-charging feature as for many kinds of work this permits the loader to be dispensed with. For such services a batch or charging hopper is furnished if desired.

The Rex 6 is a similar machine and is not furnished with loader as on account of the low height the machine can be economically charged from the ground or by barrows.

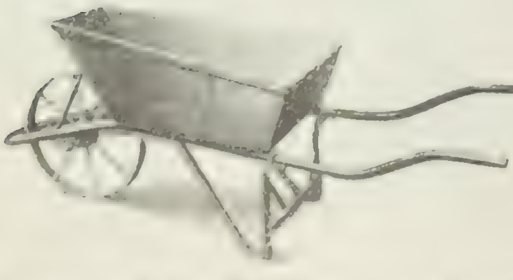


Three Types of Parker Expansion Bolts

A New Line of Expansion Bolts

When designing the Parker[1] line of expansion bolts special means to prevent the shield turning in the hole was devised. The illustration shows three typical bolts, and at the left a cross section illustrates the notched form of the shield which works like a ratchet and prevents turning. The halves of the shields are held together by a spring steel band which while flexible prevents the parts being separated by accident.

The machine bolt type is provided with nuts which interlock with the shield in such a way as to prevent the assembled unit coming apart. A line of toggle bolts is being put on the market in connection with the expansion bolts.



Sterling 2 Cu. Ft. Measuring Wheelbarrow

A Wheelbarrow for Measuring Aggregate

Proper proportioning of concrete materials by measuring in ordinary barrows is too much a matter of guess work to be approved by careful engineers and contractors.

The wheelbarrow illustrated[1] is constructed with a tray holding 2 cu. ft. which can be accurately struck off.

Compounds for Cleaning and Bleaching Concrete and Stone

The inevitable discoloration of concrete stone and tile from smoke and dust makes valuable a preparation that will economically clean and freshen these materials. The Wallior Chemical Laboratory[2] has specialized on this class of products.

Letters written to users by this magazine indicate that really valuable agents for cleaning, bleaching and repolishing concrete, marble, tile and building stone are available.

Current Prices — Concrete Materials

Portland Cement—The cement market is still below normal, and the demand is about the same as last month. Prices show a little increase. Prices given are f. o. b. cars at points named, including cloth sacks, for which, in general, 40 cts. per bbl. (4 sacks) is refunded on return in good condition. Prices per bbl. (including 4 cloth sacks) are as follows: Boston, $1.72; New York, $1.57; Chicago, $1.61; Pittsburgh, $1.61; New Orleans, $1.63, on dock; Memphis, $1.80; Cleveland, $1.75; Detroit, $1.65; Indianapolis, $1.74; Cincinnati, $1.69; Toledo, $1.69; St. Louis, $1.60; Milwaukee, $1.78; Minneapolis and St. Paul, $1.88; Duluth, $1.91; Peoria, $1.69; Cedar Rapids, $1.80; Davenport, $1.70; Spokane, $1.75; Seattle, $2.40; Portland, Ore., $2.40; Tacoma, $2.40.

Crushed Stone—$1\frac{1}{2}$-in. stone, prices per cu. yd., f.o.b. cars in carload lots, unless otherwise specified. New York, 60 cts. to 80 cts., in full cargo lots at the docks; Chicago, $1.15; Spokane, $1.00; Portland, Ore., $1.15; Seattle, $1.50.

Gravel—Prices given are per cu. yd. f.o.b. cars in carload lots unless otherwise noted. New York, 80 cts. in full cargo lots at docks; Chicago, $1.15; Spokane, $1.00; Portland, Ore., 85 cts.; Seattle, 75 cts.; Tacoma, 75 cts.

Sand—Prices are per cu. yd. f.o.b cars in carload lots unless otherwise indicated. New York, 50 cts., full cargo lots at docks; Chicago, $1.15; Spokane, 75 cts.; Seattle, 75 cts.; Portland, Ore., 85 cts.; Tacoma, 75 cts.

Reinforcing Bars—The demand for reinforcing bars continues active, but orders continue to be taken on a basis of delivery in five or six weeks, owing to the demand for large steel bars. In the Buffalo district the demand for bars is heavy, same is true of Chicago market. The general tendency of the market is that deliveries for October will be made on a basis of $1.35 per cwt., Pittsburgh, with prevailing extras for bars under ¾″ or base. The following are quotations on base bars per 100 lbs., for mill shipments from other points, f. o. b. cars: New York, $1.519; Philadelphia, $1.509; Chicago, $1.539; Spokane, $2.05; Portland, Ore., $1.85; Seattle, $1.85; Tacoma, $1.85.

Shipments from stock are being made at the following prices per cwt. f.o.b. New York, $2.00; Philadelphia, $1.90; Buffalo, $2.00; Cincinnati, $1.90; Cleveland, $1.90; St. Louis, $1.85; Chicago, $1.80; St. Paul, $1.90; Spokane, $2.35; Portland, Ore., $2.05; Tacoma, $2.15; Seattle, $2.15.

Metal Clips for Supporting Bars—$5.50 per 1,000, depending on size.

For the majority of the prices given we are indebted to the Universal Portland Cement Co., Concrete Steel Co., American Sand & Gravel Co., Chicago, and F. T. Crowe & Co., Seattle, Portland, Spokane and Tacoma.

Reinforcing bars for mill shipments are in general sold on a Pittsburgh basis; that is, at the Pittsburgh quotation plus the freight to the point in question, and with the following list of freight rates on finished material and the Pittsburgh quotation given, the price of bars at any of the points listed can be readily computed.

From Pittsburgh, carloads, per 100 lbs. to:

Albany	16.9	cts.
New York	16.9	"
Philadelphia	15.9	"
Baltimore	15.4	"
Boston	18.9	"
Buffalo	11.6	"
Cleveland	10.5	"
Birmingham	45	"
Cincinnati	15.8	"
Chicago	18.9	"
Denver	68.6	"
St. Louis	23.6	"
New Orleans	30	"
Minneapolis	32.9	"
Indianapolis	17.9	"
Kansas City	43.6	"
Omaha	43.6	"
Pacific Coast Points (Rail)	80	"

Now that the Panama Canal has been opened to traffic ocean freight rates on reinforcing bars to Pacific Coast points have been established which materially lower the delivered cost of bars from the east. The rates per 100 lbs. to Pacific Coast points for large lots are: From Pittsburgh, 61.9 cts.; Chicago, 76.5 cts.; Youngstown, 63.9 cts.; New York, 45 cts.; Bethlehem, 52.9 cts.

A wad of clay is a convenience on any concrete job. Small imperfections in form work are easily filled. A thin mixture of clay and water brushed on forms or surfaces from which concrete must be separated is very effective.

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[1] Parker Supply Co., N. Y. C.

[1] Sterling Wheelbarrow Co., Milwaukee

[2] New Orleans, La.

Concrete

Cement Age

Vol. 7 *Detroit, November, 1915* *No. 5*

For A Better Cement Show

WHEN this magazine in its Mar., 1915, issue offered friendly, and it is believed, constructive criticism upon the last Chicago show of the Cement Products Exhibition Co., it was not alone in its conviction that the Cement Products Show should show more *concrete products*.

Of machinery there is no end. Machinery of many sorts and kinds is necessary to the economical use of concrete, but if the purpose of the show is to "sell"—so to speak—the merits of concrete to the public, then the public must be shown something besides pulleys and gears, cams, levers and cables. The public wants to see concrete in its numerous applications and if the public does see concrete to good advantage, the builders, who are primarily interested in seeing the wheels go round, will have more occasion to buy the machinery. But if a show does not convert to an appreciation of the value of concrete the architects, engineers and owners, who, heretofore, have not been making the most of concrete's possibilities, then the show has failed in giving the constructors proper occasion to invest in more concrete-making equipment. The machinery is absolutely necessary, but the men who make it and sell it should have the very liveliest interest in having the show an educational exhibit on a much broader scale.

Joint Exhibit at Cement Show

ALTHOUGH at this writing no detailed announcements have been made by the Cement Show management, it does appear that a way has been found to do something impressive in showing visitors at the Cement Show some examples of concrete work. Twenty-seven Portland cement companies are to have a joint exhibit. While substantial exhibits of actual concrete work have been made heretofore by individual cement companies, it is impossible for one company to do so thorough and comprehensive a job of showing off the material concrete to good advantage as 27 companies can do when they get together and pool their efforts. While competitive effort in some directions insures the most notable progress, there is no question that 27 companies can accomplish jointly at a cement show what 27 individual companies would make a failure of, through the necessary limitations of disjointed efforts in giving related and thoroughly comprehensive results.

Get Ready

WITH the approach of winter comes a slowing up or cessation of outside work, affording a more or less welcome leisure. There is less temptation to spend one's time out of doors; the pipe and the easy chair hold added attractions.

This is the time to stop and consider what has been accomplished during the year, to note the points where work has fallen short of what was expected, to plan systematically, adding to one's business and technical knowledge during the winter months, to devise better business and more efficient construction methods intended to make next year's record better than that of the year just past.

To many, the business conditions of the last two years have meant discouragement and hardship. Others have been more fortunate in keeping conditions at, or near to, normal. One thing seems assured; there is already upon us an upward sweep in business that is going to tax the builders of the country to keep the pace. When operations are postponed, as many have been, there must come a time of lively operations to make up for lost time. It behooves the engineer and the office man to make sure during the early winter months that he is fully abreast of the most recent and efficient methods, to store away for future need mentally, or even better, in the form of systematically recorded knowledge, what has been gained from the study of the printed page and from the great school of experience.

The contractor should provide suitable storage for tools and machines, he should use the ensuing months to see that each tool and piece of equipment is put in first-class shape ready for instant and efficient use. He should also anticipate, so far as possible, his needs for new equipment. Thousands of old mixers and other machines have been nursed along during the last year that would under normal conditions have been replaced. Now is the time to study the machines available so that when the contract is closed that makes the equipment necessary, there will be no need to spend valuable time in making a decision that can be studied to better advantage now. Get catalogs, and *study* them. They are mines of information developed by experts to give knowledge. File them where they are instantly available when the need comes—for it is surely coming.

Beware of Chilled Cement

THESE nippy autumn nights are cold enough to injure surface finish and frost often penetrates to a considerable depth, to the detriment of the work. The dangers of damage to structures by the freezing of concrete are clear to everyone having to do with construction work; the dangers of using cold concrete, while fully as real, are often not recognized. The danger comes from two sources, chilled aggregate and cool (even though not freezing) nights. Every autumn has brought news of failures resulting from too early removal of forms. After Oct. 1, when the nights are cool, with occasional frosts which chill the aggregate, the concrete hardens much more slowly than it did just a little earlier in the season. Succeeding nights still further retard setting and the time for safe removal of forms is greatly deferred.

Elsewhere in this magazine are summarized precautions necessary to successful winter work and methods by which failures may be avoided. Just now every man responsible for concrete work must use double vigilance to avoid "another concrete failure" which, being interpreted, means lack of care on the part of those responsible.

Why Spoil Good Cement With Poor Aggregate?

GOOD concrete, like the proverbial chain, is no stronger than its weakest part. Every material entering its composition should be the very best available. Cement has been standardized. It is required to pass severe mill tests and is often subjected to further tests by the engineer in the field. Faulty concrete can only occasionally be traced to poor cement.

Aggregate has too often not been considered seriously. The product of the local bank or river has been used with a confidence often misplaced. Bank deposits of sand are seldom entirely clean and if they are clean the methods used in taking out material often result in a considerable admixture of top soil. Bank gravel is seldom evenly mixed. It is usually in more or less distinct layers of varying size. It is then obvious that to secure uniform and standard concrete the bank material must be screened and scientifically proportioned.

Concrete engineers and contractors are demanding material suited to their needs. They require a standardized material with definite deliveries at moderate cost. These are the conditions to be met by the modern gravel plant. They offer opportunities for the display of a high degree of engineering and constructional skill, coupled with sound business administration.

The Shining Dimes

LARGE work affording proper storage facilities can and is making use of the advantages afforded by bulk cement, but there are still hundreds of jobs where the cement sack remains.

Should a contractor find on his job a number of shining dimes scattered about on the ground and discover that these dimes were to be deducted from his profit, he would undoubtedly call to account the men responsible. The abuse of cement sacks, on most jobs, calls forth no such results. Yet it is usually easy to arrange a dry, convenient place where the sacks as soon as empty and shaken can be laid until a bundle is accumulated. They should be tied securely as soon as possible, as once bundled they are not likely to be used wastefully. The cement sack represents a considerable investment to the contractor and the loss from its abuse can easily run into worthwhile amounts.

The Position of the Engineer

In addressing "Triangle," a fraternity of civil engineers, Ira Osborne Baker[1] deplored the fact that engineers have not as a body taken the place in the activities of public life to which their attainments clearly entitle them.

He said in part:

> The unusual requirements for admission to a collegiate engineering course, and also for graduation, are higher than are generally required for the lawyer or the doctor, and the engineer's education is usually more than that of some influential preachers; but nevertheless these men occupy a position of greater distinction in the community than does the engineer. It is seldom that an engineer takes a leading part in the discussion of questions relating to municipal franchises for street railroads or electric lighting, even though these are engineering matters; nor it is usual that the engineer has as prominent a position in the discussion of questions relating to city water supply or sewage disposal as the physician, even though these matters are in the field of the engineer. Again, the engineer is not as prominent in the discussion of moral and civic questions as is the preacher, although the engineer ought to be interested in public affairs.
>
> Who make the laws for the city or the state? I think you will all agree that the engineers are not represented in such work in proportion either to their numbers or their intellectual ability; it would not be difficult to show that in many cases state legislation has been unfortunate in that it has not been guided by sound engineering wisdom. In how many states are there engineers on the railway commissions or in the public utilities commissions? Not many railway engineers rise to the higher administrative positions, at least not in proportion to their own numbers and to the number of such positions.
>
> Of course, there are noted individual exceptions to the claim that the engineer does not receive his proportion of the higher administrative positions, and there are also noted examples of engineer's organizations rendering valuable aid in public affairs; but nevertheless I think the views I have stated are substantially correct for the representative engineer and engineering organization.
>
> I am persuaded that the chief reason why the engineer does not attain to the position in the public estimation which he might occupy is because of wrong ideals. The representative engineer magnifies the importance of technical matters. In college he is insistent upon acquiring a so-called practical education, that is, he desires to specialize and to take only the subjects immediately connected with his chosen profession. As a consequence, he lacks breadth of view and is weak in knowledge of non-professional matters. Too often he has sought to perfect himself in technical details to the neglect of a knowledge of political procedure, of business methods, of labor conditions, or of social problems. Further, he is often seriously deficient in the ability to use correct and forceful language.
>
> By continual care and practice, he should cultivate the ability to express himself in writing and in oral speech in clear, concise, correct English.
>
> He should extend his horizon by reading and study of industrial and political and social science, economics, labor problems, principles of banking, rate regulation and other vital subjects that will suggest themselves.
>
> He should use care in selecting his associates. A leading American civil engineer who was just stationary in his professional career said that he could not afford to go to the annual convention of the Am. Soc. of Civ. Eng. because he wanted to join a certain club, the leading club in the city in which he lived, for which the entrance dues were $600. He wanted to make the acquaintance of the men in that club, for they virtually controlled the commercial affairs of that metropolis. This man did not neglect technical societies, but he did join the club referred to, and now he has an annual salary of $50,000, and gets some large fees besides. The initiation fee to the club was not wasted; and his success was not simply luck.

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[1] Prof. Civil Engrg., Univ. of Illinois, Urbana, Ill.

Screening and Washing Plants for Supplying Clean and Well Graded Aggregate

The time has come when the concrete contractor should be able to secure aggregate of unquestioned quality in sizes suitable for his work. Delivery is of first importance and the gravel dealer should be in a position to take care of his orders beyond a question of delay.

In Sept., 1915, CONCRETE *published discussions as to the proper stocks and sizes to be carried by dealers, and in October a correspondent pointed out some of the conditions that must be considered in financing a gravel or stone plant. Descriptions of several successful plants seem to follow as a logical sequence.*

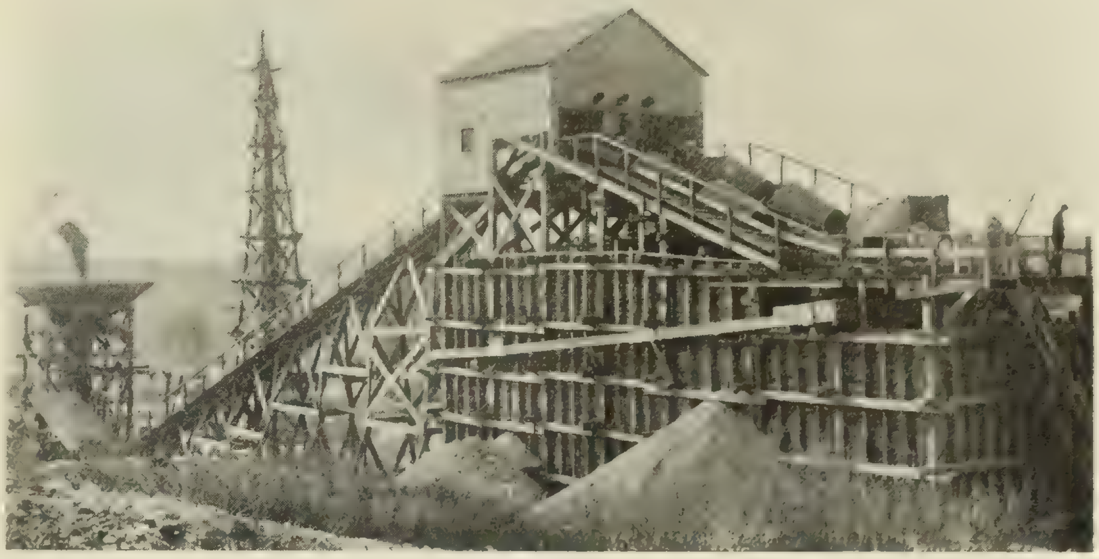

FIG. 1—GENERAL VIEW OF DAVIES & BREW GRAVEL PLANT

Equipment and Operation of Plant at Waukesha, Wis.

BY STANLEY E. BATES[1]

Around Waukesha, Wis., are located large deposits of sand and gravel designated by the state engineering authorities at Madison as the finest in the state for concrete work of all kinds. Many pits have been opened in that vicinity, most of them within a mile or two of the city. The latest one, put in operation July 1, 1915, uses an electrically operated drag-line and represents the latest principles in design and equipment.[2]

This is known as the Davies and Brew plant and is on the site of an old pit that had once been worked on a small scale but later abandoned. The area of land owned by the new company comprises 18 acres, the larger part of which contains gravel to a workable depth of 50′ or more, depending on whether or not it is found practicable to excavate below ground-water level.

THE DRAG-LINE

For excavating the gravel, a Shearer & Mayer drag-line cableway excavator[2] is used. The essential features of this apparatus are a bucket and carriage running on a slack-line cableway, a rigid mast and a hoist. The bucket is said to be the largest of its kind ever constructed, having a capacity of 2 cu. yds. It is equipped with five heavy teeth on the cutting edge. Other details of the bucket, carriage and chain mountings are shown in an accompanying illustration.

The mast or tower (Fig. 1) which supports the near end of the drag-line cable, is 86′ high. The foundation is of concrete, the shape of a letter H in plan, and 3′ 6″ deep. The center post is built up of 16-in. x 16-in. timbers, spliced together end to end and reinforced. Outside of this is a framework, the vertical members of which are 8-in. x 8-in. timbers, connected at intervals of from 9′ to 14′ by horizontal 8 x 8's and, near the top, 6 x 8's. For diagonal bracing 2 x 10's and 2 x 8's are used. The center post is connected to the other framework at every panel by two 8 x 8's.

The mast is guyed by three main and two auxiliary cables attached near the top and running to dead men located about 100′ distant from the base. The three main guys extend out on the opposite side of the mast from the bucket cableway and consist of $1\frac{3}{8}$-in. wire rope.[3] The auxiliary guys are of $\frac{7}{8}$-in. wire rope and go in the opposite direction.

At the top of the mast are attached the blocks carrying the drag-line and tension cables. The pulley for the former is 18″ in diam. and others 14″. The drag-line cable[3] is $\frac{7}{8}$-in. wire rope and runs from the forward drum of the hoist around the sheaves and thence to the bucket. The $\frac{3}{4}$-in. tension cable runs from

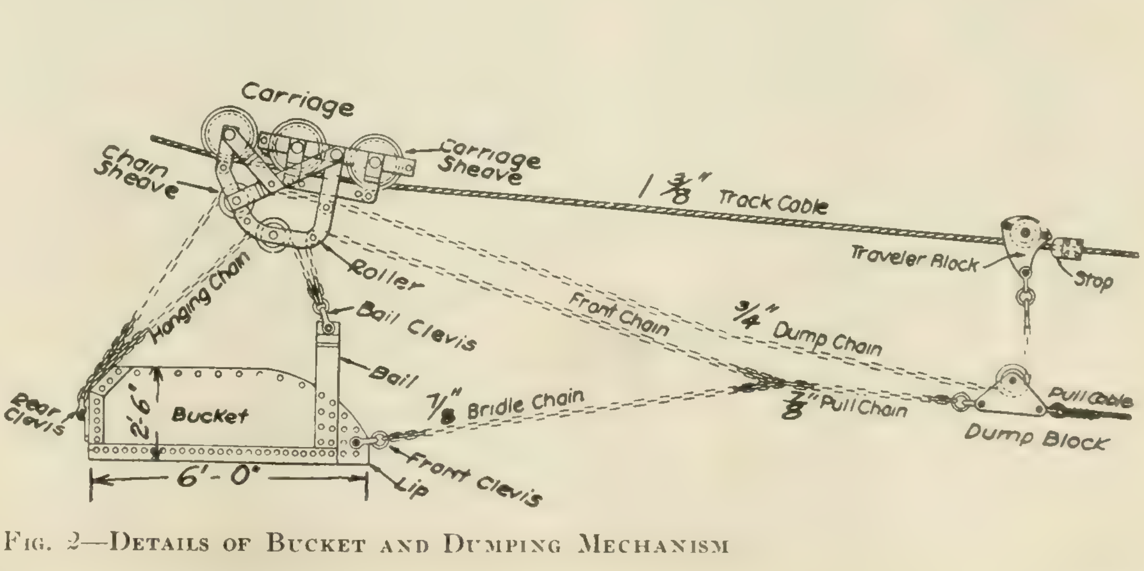

FIG. 2—DETAILS OF BUCKET AND DUMPING MECHANISM

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[1] Assoc. Mem., West. Soc. of Engrs., Chicago

[2] Sauerman Bros., Chicago

[3] American Steel & Wire Co., Chicago

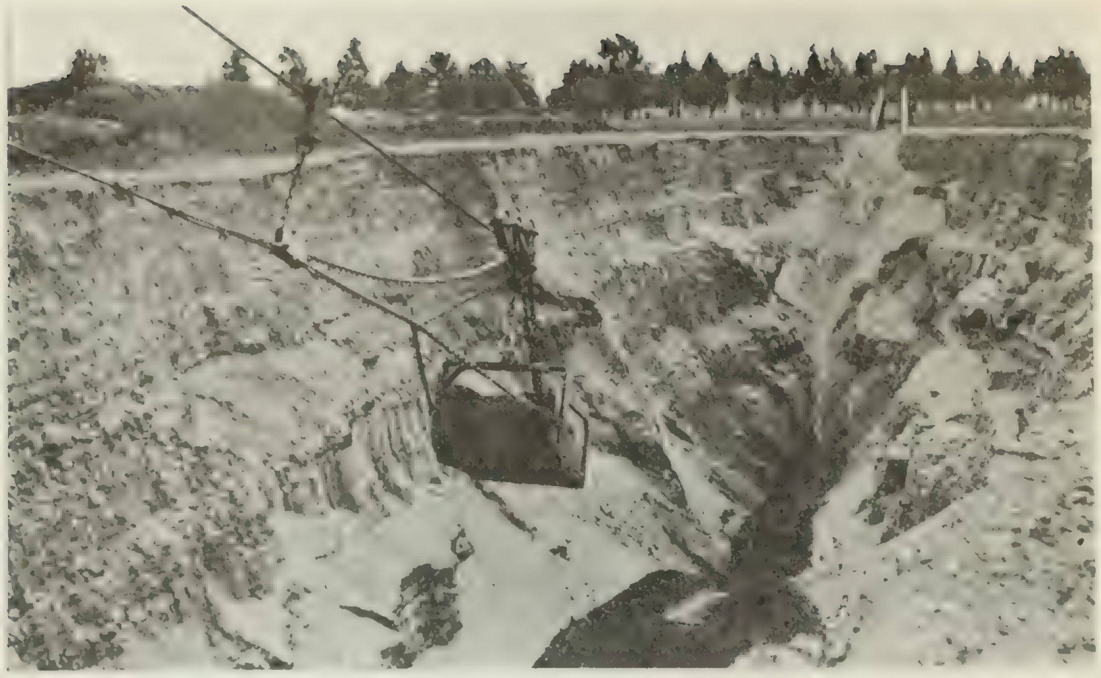


Fig. 3—Gravel Pit, Showing Bucket Leaving with Load

Note layers of various gravel sizes, showing need of grading bank gravel

the rear hoisting drum to a set of falls, thereby furnishing means for slackening and tautening the track cable. The latter is of $1\frac{3}{8}$-in. wire rope about 500′ long, anchored at the far end to a dead man.

The 75-h. p. electric hoist[4] takes current at 440 volts from a 2,200-volt power line stepped down by three transformers at the plant. A friction clutch of the band type transmits the power to the drums.

The hoist is located in an 18-ft. x 20-ft. frame building about 100′ from the tower, at right angles to the cableway, and has two speeds for operating the drag-line cable, the high being three times the low. This is of advantage in drag-line work, as it gives great power at low speed for digging, and then, when the bucket is full, the machine is thrown directly into high by a simple motion of a lever and the bucket is carried rapidly to the dumping point. Though the hoist is placed so that the operator cannot see the bucket at any time except just as it is dumping its load, the operation is so simple that this causes no inconvenience and a full load is secured each time.

GRIZZLY AND CRUSHER

The hopper into which the gravel is dumped from the bucket is 30′ from the ground, supported by a timber framework of 10 x 10's, with 2-in. x 10-in. diagonal bracing. This framework also supports the grizzly, crusher and other machinery incidental to preparing and loading the material on the belt. Foundations are all of concrete, 3′ 6″ below ground.

The hopper measures 13′ 6″ x 17′ 6″ across the top. Each side has a slope of 45° and is made of 3-in. plank resting on 2-in. x 8-in. beams placed 2′ o. c. Through the bottom of the hopper the material passes down a vertical chute, 3′ x 3′ on the inside to the grizzly, the flow being controlled by a gate of sheet steel arranged to slide horizontally across the bottom of the chute. The grizzly is set at an angle of 45° and is 4′ wide and 7′ long. The bars[5] are of arrowhead shape, $2\frac{1}{2}$″ deep, 1″ wide across the arrow, with a considerably thinner shaft below, designed to prevent clogging, and set $1\frac{1}{2}$″ apart in the clear, being held in place by transverse rods and cast iron spacers.

All the stones over $1\frac{1}{2}$″ in diam. are caught by the grizzly and chuted forward directly into a gyratory crusher which is placed immediately below the lower end. The remaining finer material passes through the bars and behind the crusher into a hopper, where a reciprocating plate feeder operated by an eccentric distributes it evenly to the belt.

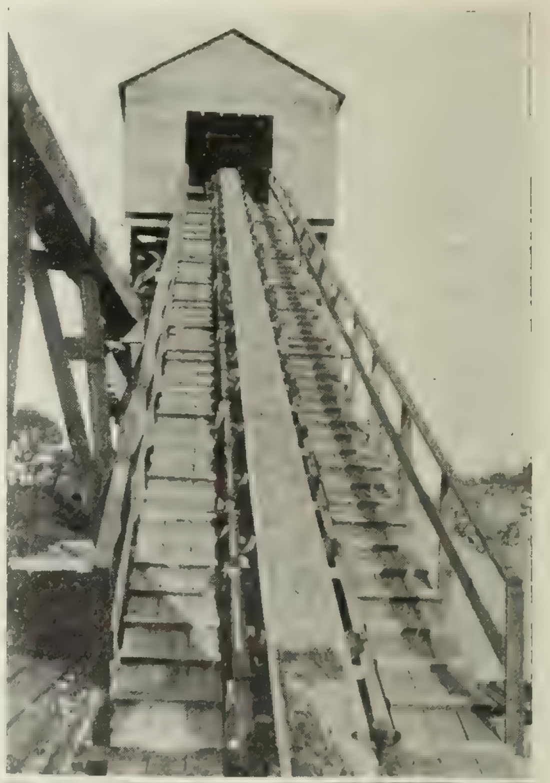
The crusher is a No. 5 Telsmith[5]. Its particular feature of construction is that the central shaft and the head do not rotate. The former acts simply as a bolt, clamping the upper spider casting to the lower frame. The eccentric is located inside of the head and as it revolves, a parallel motion, equal at the top and bottom, is imparted to the head. This is of advantage in crushing the large, smooth, hard boulders found in gravel pits of this kind, as there is no opportunity for slippage.

The material passing through the crusher drops directly onto the belt in front of the feeder described above and, therefore, on top of the fine material.

BELT CONVEYOR

The belt[6] is slightly over 157′ long c. to c. of the end pulleys. It is 20″ wide and made of rubber and canvas duck, five-ply, and with $\frac{1}{8}$″ of extra rubber on the carrying side. The belt conveyor operates at a speed of about 325′ per min. up an incline of nearly 22° and has a capacity of 100 cu. yds. per hr.

The troughing idlers are spaced 5′ apart. The brackets holding the ends of the shafts are bolted to 4-in. steel channels to preserve their alignment as the supporting timbers dry out and warp. Guide rollers carried on bent shafts of cold rolled steel are about 20′ apart. Return idlers are spaced 12′ 3″ apart. All idler shafts are of cold rolled steel running in closed end babbitted boxes. Lubrication is by means of grease cups, making the care of the con-



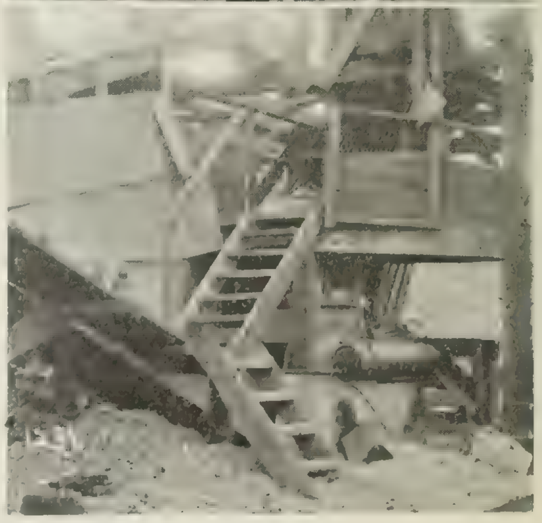


Fig. 4 Conveyor Belt Carrying Gravel to Screens

Fig. 5 Detail at Lower End of Conveyor

Note grizzly and crusher at head of upper flight of steps veyor a simple matter. The belt is driven from the upper end.

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[4] Thomas Elevator Co., Chicago

[5] T. L. Smith Co., Milwaukee

[6] Manhattan Rubber Mfg. Co., Chicago

WASHING AND SCREENING

The washing and screening plant is located on top of the bin structure, taking the material directly from the belt. There are six screens[5] arranged in two parallel series, of the conical type, each 6′ long, 4′ 6″ in diam. at the large end and 3′ in diam. at the small end. The perforations in the first screen are 1½″ in diam.; in the intermediate, ⅜″, and in the last, ¼″. Each series of screens is carried on a single shaft, driven from the upper end. They turn in opposite directions.

Passing off from the end of the belt, the material falls into a two-way chute, at the top of which a stream of water thoroughly saturates it. The chute discharges directly into the first set of screens. Near the upper end of each, several short lengths of angle iron are bolted spirally to the inside. These angles tend to hold the gravel in the screen a long time and the extra rolling and tumbling about grinds off all the mud, while a stream of water plays on the material and assists in the separation.

The material passing the 1½-in. holes is carried on through a steel trough underneath the first screen to the second screen. The larger stones retained are given an extra washing by another jet of water just before they leave the cylinder and they then pass down into a chute as described below. At this point there should be described a feature of this plant, not put into the original design, but worked out by the superintendent on the job. The reasons for this were as follows:

After the plant had been in operation for a few weeks, it was found that in the largest size of stone produced, i. e., that over 1½″ in diam., there were many large, flat stones, sometimes 4″ or more in diam. but only ½″ or so thick, which succeeded in passing through the grizzly and so into the finished material. These were objected to by purchasers of the stone. It was also found that the conical 1½-in. perforated screen retained some stone less than 1½″ in diam. As the largest stone is the hardest to sell, it was desired not to increase the amount produced by an admixture of slightly smaller stone, so the following method was devised to remedy these two conditions:

An ordinary cylindrical screen, 12′ long and 2′ in diam., with 8′ of 1½-in. and 4′ of 2½-in. perforations was installed immediately below the first set of washing screens. The large material from the latter is chuted into this cylindrical screen and, with 8′ of surface to pass over, practically all of the stone smaller than 1½″ is taken out. The remainder passes on to the 2½-in. perforated section where all but the large, flat stones, described above, pass through the holes. The flat stones are carried out of the end of the screen and through a chute, outside of the bins onto the ground.

Returning to the main washing operations: The materials passing through the holes of the first screen go to the intermediate, where the operation is similar to that in the first, except that there are no angles bolted to the inside, and two streams of water instead of one play on the 1½-in. stone just before it leaves the screen and falls below into the bin.

The operation of the third screen is similar.

The material passing through the holes of the latter is sand and muddy water, which go into settling tanks. The muddy water flows off through the spillway and is taken by a trough to some low ground about 200′ distant from the plant. The sand settles to the bottom of the tank. When the deposit becomes sufficient to overbalance the counterweighed valve gate in the bottom, the valve opens and the clean sand is discharged directly from the tank into the sand bin.

With the screening plant as described above, material is produced in the following sizes:

Diameter (in.)		Local Commercial Name
Max.	Min.	
2½	1½	———
1½	⅜	———
⅜	¼	Roofing gravel
¼	down	Sand

THE BINS

The bin structure is of timber throughout, resting on concrete foundation walls and piers. Both the outer walls and the interior partitions are 3-in. x 10-in. plank to a height of 17′ 3″ and 2-in. x 10-in. plank above that point to a total height of 38′. All bins are 18′ across and about 16′ long, except the bin for roofing gravel, which is about 11′ long. The total length of the structure, exclusive of the belt conveyor trestle, is 62′, and the total capacity 450 cu. yds.

LOADING CARS

The bins discharge through steel chutes directly into railroad cars, a spur from the Minneapolis, St. Paul & Sault Ste. Marie R. R. running from the main line to the plant. There is no provision for loading into wagons for local delivery.

There are seven chutes in all, two from each of the larger bins and one from the roofing gravel bin. The chutes from the two bins holding the largest sizes of stone are perforated with ¼-in. holes. As the material is loaded into the cars a stream of water from a nozzle directly over the chute is turned onto the material, giving it a second wash. It would scarcely be possible to wash gravel cleaner.

WATER SUPPLY

The water supply for washing the gravel is obtained from a well located close to the tower. This well is circular, 16′ in diam. on the inside, 12′ deep, open at the top and curbed with a wall of concrete 10″ thick.

The pump[7] is of the single-stage, double-suction, centrifugal type, equipped with a 6-in. suction pipe and delivers water to the top of the bins through a 5-in. pipe line at a rated capacity of 750 gal. per min. The pipes delivering water to the various screens are all 1½″ in diam. The discharge ends are flattened into wide, thin openings, giving a heavy spray at a good velocity.

MOTORS

The plant is electrically operated throughout. Aside from the hoist described, the power units[8] are as follows: One 35-h. p. motor running the crusher and oscillatory feed; one 25-h. p. motor running the screens and belt a and 35-h. p. motor driving the centrifugal pump.

The capacity of the plant is between 30 cars and 35 cars, or more than 1,000 cu. yds. per day if necessary. Up to the present time, however, there has been no demand for a maximum output. This, together with the fact that it always takes some time for any plant to get working smoothly, is responsible for the fact that the average so far, has been between 12 cars and 14 cars, or approximately 400 cu. yds. per da.

THE PIT

As shown in the accompanying illustration, there has been dug by the bucket a hole over 400′ long, 100′ wide and 50′ deep. The sides stand at a very steep angle, owing to the bedding of the gravel, the various strata being quite thin. When as much material has been excavated as possible with the present location of the drag-line, the dead man will be moved 75′ or so to the right or left, and, if necessary, the mast will

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[7] The American Well Wks., Aurora, Ill.

[8] Westinghouse Electric & Mfg. Co., Pittsburgh

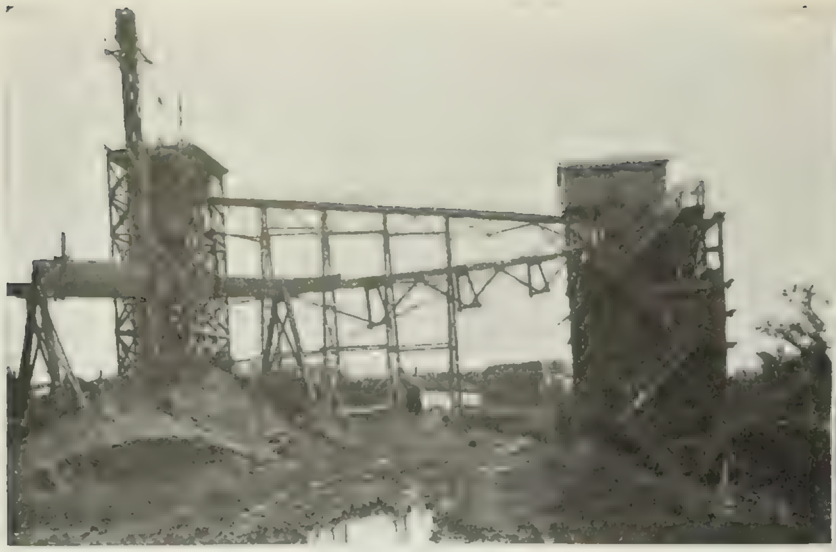

Fig. 1—Gravel Plant Looking Toward the Pit

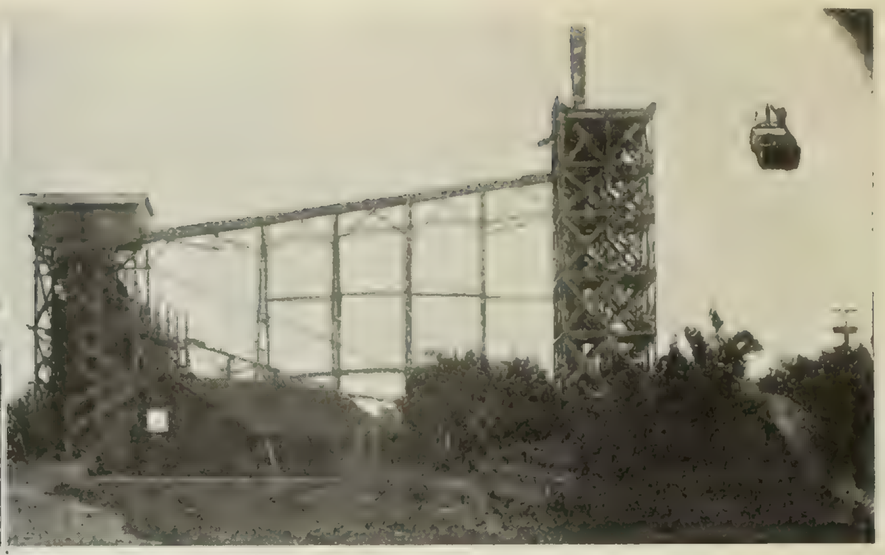

Fig. 2—General View, Showing Bucket Nearly Up to Hopper

also be moved a short distance in the opposite direction so that the bucket will dump into the hopper without changing its location. In this way excavation will be carried on in a circle around the hopper as a pivot, the radius being about 400′.

The gravel lies close to the surface of the ground, the average amount of stripping required being 2′ 6″. This work is done by contract at a price of 20 cts. per cu. yd., which includes a 250-ft. haul.

COSTS

For the operation of the plant 7 men are required, as follows: Superintendent, engineer for hoist, one man at the grizzly and crusher, one man tending the screens, two men loading cars, one repair man.

The cost of producing sand and gravel at the Davies & Brew plant is given in the table. It should be borne in mind that these are actual figures, not ideal figures based on perfect conditions and working at full capacity. For figuring interest and depreciation it is assumed that the plant will run 180 das. out of the year.

Cost of Excavating, Washing, Screening and Loading Gravel on Railroad Cars at the Davies and Brew Gravel Plant, Waukesha, Wis.

		Per 10-hr. da.
Labor—		
Engineer at 27½ cts. per hr.	$2.75	
3 men, at 25 cts. per hr.	7.50	
1 man, at 22½ cts. per hr.	2.25	
1 man, at 20 cts. per hr.	2.00	
		$14.50
Superintendence		6.00
Running Expenses—		
Electric current	$19.00	
Incidentals, such as oil, etc.	.40	
		19.40
Overhead—		
Interest on $20,000 investment at 6%	$ 6.67	
Depreciation on $20,000 investment at 10%	11.11	
Insurance, $60.00 per annum	.33	
		18.11
Repairs		2.00
Total cost per da.		$60.01
On the basis of a production of 400 cu. yds. per da.:		
Cost per cu. yd. loaded on cars		15 cts.

A Gravel Washing Plant With Unique Features

(Staff Article)

The fact that every gravel washing plant is an individual problem where natural conditions should be used to the best advantage, is strikingly shown at a plant owned and operated by F. L. Ward, on the Ferniehurst Apple Orchard Estate, about a mile from Pontiac, Mich.

The deposit of sand and gravel is of glacial formation, with a very light overburden. The property consists of a broad ridge with the Grand Trunk R. R. skirting its edge about 15′ below the general level of the property. A large, clear stream winds around the plant on three sides, affording ample water supply and run-off for the soiled water. The depth of the gravel is unknown; the present pit is about 30′ deep to the surface of the water and the gravel is now being taken out nearly 30′ under water. The material is, in general, fairly clean in the bank, but there are dirty streaks which make washing necessary.

GENERAL DESIGN

After a consideration of the existing conditions, a drag-line excavator was decided upon as the most economical means of securing the materials. In order to make available the largest amount of gravel and also to assist in securing the necessary elevation for the drag-line, the mast was located on top of the ridge about 100′ from the railroad. The bins were obviously to be located at the side of the track; the steep bank at that point is an advantage, as it makes the bins and screens exceptionally easy of access. This arrangement necessitated means of transferring the material from the hopper, into which it is dumped by the drag-line bucket, to the screen. This transfer is often done by a conveyor belt but in this plant it is successfully accomplished by means of a flume built of 2-in. planks supported on timber bents and carried over the wagon road by a truss.

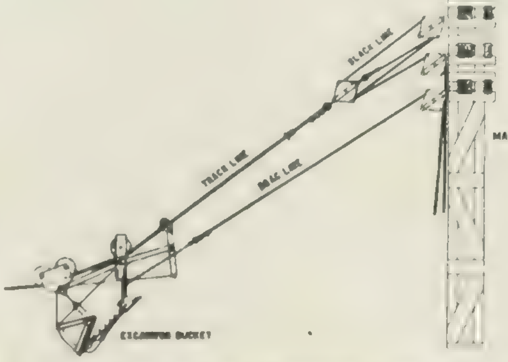

Fig. 3—Detail of Bucket and Mast

This flume is at such an angle that the gravel is carried rapidly along by a powerful stream of water which gives an exceptionally thorough washing before the screens are reached. This feature is unusual, if not unique, and was suggested by the wide experience of the plant superintendent in Alaskan hydraulic mining operations.

EQUIPMENT

The mechanical equipment is as follows: The drag-line cableway[1] is supported by a 90-ft. mast built up by four 8-in. by 8-in. hard pine sticks latticed by 2-in. planks and heavily ironed. The mast is back-stayed by two 1¼-in. wire ropes[2] which take the direct pull. There are also two ¾-in. guys set at a wider angle and two ¾-in. fore-stays. The 1½-yd. rear dumping excavator bucket[1] operates over a 500-ft. 1½-in. track cable.[2] This cable is anchored at the lower end at one side of its line of operation; a bridle is attached to the track line at the lower end of the pit and anchored at the other side so that the line of travel of the bucket can be changed to cover considerable width in the bottom of the pit. The track line is controlled at the mast by a set of falls operated by one drum of the double drum hoist; the drag-line is operated by the other drum. The power plant consists of a 50-h. p. two-speed, double drum electric hoist,[3] which is located in a small building about 40′ from the mast, at right angles to the track cable. Through a skylight located in the roof to command a view of the top of the mast and hopper, the operator can watch the bucket when in dumping position. This style of hoist has been developed to meet conditions found in drag-line cableway excavator work and has a slow digging speed and a rapid trolley speed. The advantage of this arrangement is apparent, as in digging the pull is increased three-fold, which makes it possible to dig very hard material. The rapid trolley speed makes it possible to make the trip to the plant quickly.

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[1] The Raymond W. Dull Co., Chicago

[2] John A. Roebling's Sons Co., Trenton, N. J.

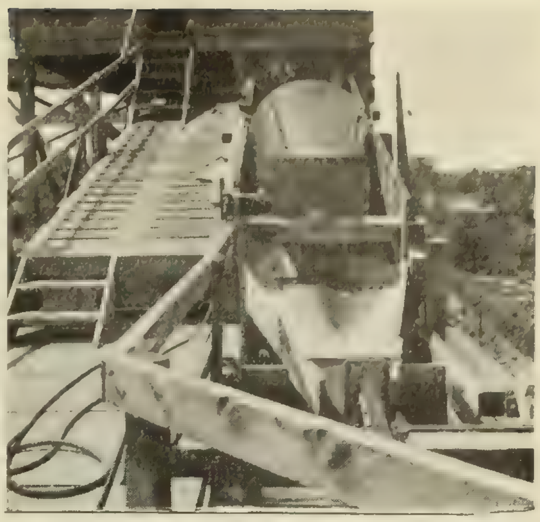

Fig. 4—The Screens, Sand Separator in Foreground

Fig. 5—The Pit Bucket Just Starting with Load

The bucket drops the material into the hopper 64′ above ground, from which it is fed gradually to the flume. A heavy stream of water strikes the gravel as it leaves the hopper and rolls it through bars placed in the flume at this point to take out very large stones. A pipe extends along along the bottom of the flume for about 25′ and is drilled with holes, permitting the water to boil up through the stream of gravel and still further aid in the washing. The water is supplied by means of a high lift centrifugal pump[4] direct-connected with a 25-h. p. motor.[5] This operates at great efficiency and the stream of water at the hopper is delivered at high pressure. The main line is of 6-in. wrought iron pipe.

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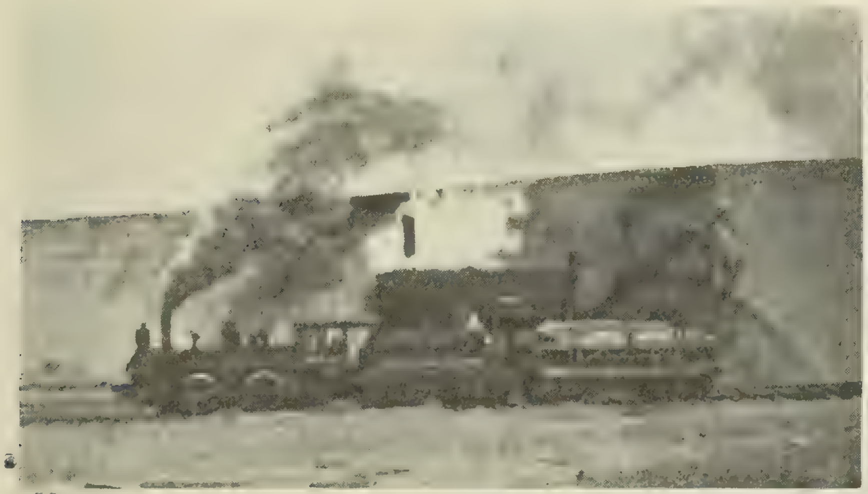
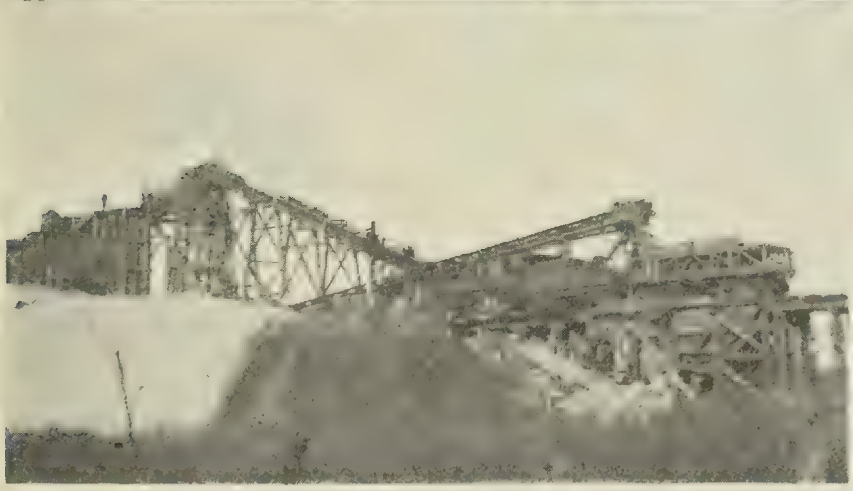
[3] Thomas Elevator Co., Chicago

[4] American Well Works, Aurora, Ill.

[5] General Electric Co., Schenectady, N. Y.





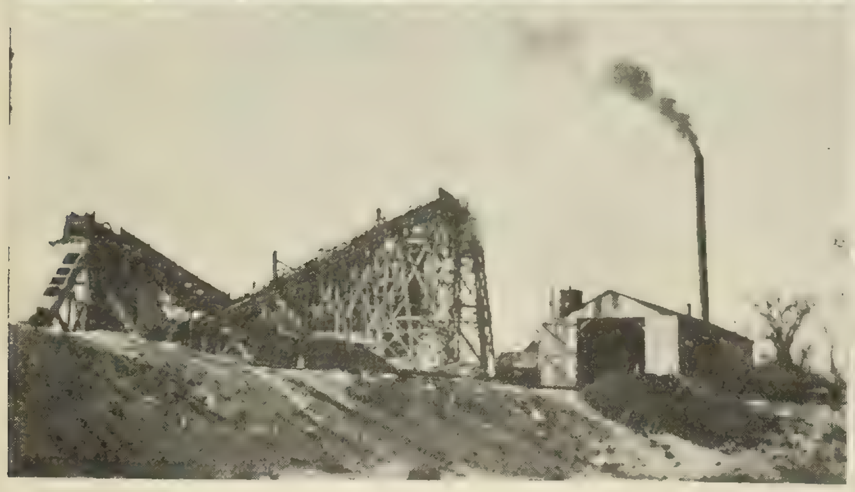
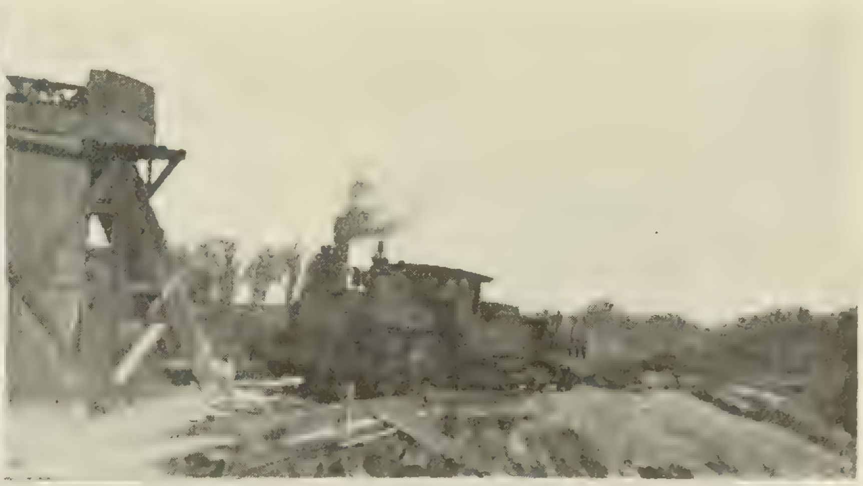
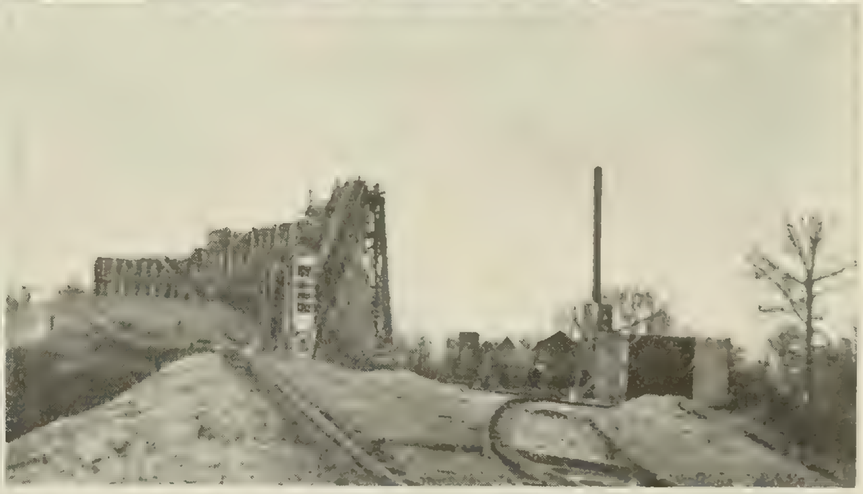


Fig. 1—Digging and Loading Gravel
Fig. 2—Dumping Gravel Into Hopper
Fig. 3—General View, Showing Power House





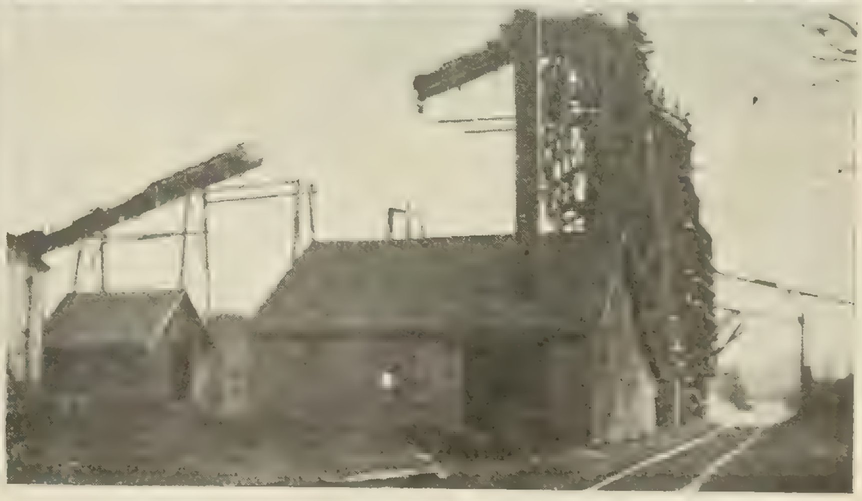


Fig. 4—Delivering a Car at the Hopper
Fig. 5—Showing Conveyor and Locomotive Stall
Fig. 6—Bins and Power House, Side View of Conveyor

The washing equipment consists of two 63-in. x 31½-in. x 84-in. inclined conical gravel washing screens,[1] operated by a 15-h. p. motor,[5] which make two grades of gravel, and a 72-in. conical sand separator[1] which delivers the sand to the storage. The sand separator is a very ingenious device consisting of a sheet steel cone suspended from the timber bin and screen frame. At the bottom is an outward opening valve which allows the sand to accumulate until it overcomes a counterweight, when it escapes until the reduction in weight closes the valve. The soiled water flows away at the top of the separator, where a baffle plate prevents loss of sand.

DELIVERING THE PRODUCT

The material is delivered from the bin structure, which is 20′ x 40′, 38″ high, through steel gates and spouts[1] directly into the cars on the side track along the side of the plant. The material is practically all absorbed locally, most of it going into road construction. Gravel is sold at a price of 65 cts. and sand at 35 cts. per ton, f. o. b. the plant. The total cost of the plant was about $15,000, and its daily capacity is about 10 cars. The plant force consists of one superintendent, an engineer and two men. It is expected that later, a crusher will be installed to take care of oversize materials, of which a considerable amount has accumulated. It is too early to give detail costs, as the entire season's output will need to be averaged for accurate data. Mr. Ward expresses himself as being well pleased with the plant and satisfied that it will prove a sound investment.

Fig. 7—The Pump House

Fig. 8—The Intake

Steam Shovel Digs Gravel For Plant At Coleman, Ill.

By R. P. Duffy[1]

Two gravel plants owned by the Richardson Sand Co. are located at Carpentersville, Ill., and at Coleman, Ill. Their combined capacity is 60 cars to 70 cars, of which the Coleman plant, here described, delivers from 25 cars to 30 cars, or about 900 cu. yds.

THE MATERIAL

The gravel deposit lies in the valley of the Fox River and above water, so that it can be worked dry. The working face of the bank is about 40′, as can be seen in Fig. 1.

PRODUCTION METHODS

Material is dug with a Marion[2] A steam shovel, with a 1½-yd. dipper and loaded on a 25-cu. yd. Roger ballast dump-car[3] which is drawn by a 35-ton Manchester locomotive[4] to the screening plant about ½ mi. distant, where it is dropped into a receiving hopper under the track, as shown in the illustrations. From the receiving hopper the material is fed to a 28-in. 8-ply Rexall conveyor belt,[5] about 300′ long, which carries it to the top of the bin structure, about 85′ high, where it is delivered to the screens.

THE SCREENS

The screens are cylindrical, 9′ x 4′, of perforated steel, in sections. They are interchangeable, so that by arranging them in different combinations material can be graded in various ways to suit orders. The following sizes of perforations are used as needed: 2-in., 1½-in., 1¼-in., ¾-in., ⅜-in. and ¼-in. These screens are specially designed and made to order and are used in such combinations as will produce maximum quantities of sizes most in demand. A typical screen set may be assumed for producing the size known as No. 8, a mixed gravel from 1¼″ to ⅜″ in diam., roofing gravel ¼″ to ⅜″ and sand from ¼″ down.

Screen No. 1, 1¼-in. holes, would be used at the head of the line and screens out all material over 1½″ and chutes it to a No. 3-D Gates breaker[6] and a No. 4 McCully standard crusher[7] set to make 1½-in. stone, which is returned to the receiving hopper by a belt conveyor.

As the material enters the screens it is washed with quantities of water delivered by a 4-in. two-stage centrifugal pump,[8] at the rate of 500 gals. per min. The washing is continued throughout the entire screening process.

The gravel which passes the 1½-in. holes is caught in a steel flume and delivered to a screen with ⅜-in. perforations, which removes the gravel above ⅜″ and passes it to the storage bins. The fine material is passed to a third set with ¼-in. perforations, which removes the sand and delivers the roofing gravel to storage. The sand is passed to a sand separator, from which it reaches proper storage.

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[1] Sec., Richardson Sand Co., Chicago

[2] Marion Steam Shovel Co., Marion, Ohio

[3] Rodger Ballast Car Co., Chicago

[4] American Locomotive Co., N. Y. C.

[5] Imperial Belting Co., Chicago

[6] Allis-Chalmers Co., Milwaukee

[7] Power and Mining Machy. Co., Milwaukee

[8] Kingsford Fdry. and Machy. Co., Oswego N. Y.

New Station at Corozal Nearly Ready for Use

The waiting platforms of the new concrete railroad station at Corozal have been placed in use, the roof and walls are completed and application of finishing plaster is in progress. The general features of the Corozal station are in harmony with the design of the new station at Balboa Heights, both using concrete throughout and both supporting the roofs over the platforms on cantilever beams, supported on single or double rows of columns.—*Canal Record.*

The following from a bulletin issued monthly by the Master Builders' Assn., of Boston, is worthy of careful thought:

> At present, when so much is heard of movements for promoting the interests and industries of special cities or districts, owners should have their responsibilities impressed upon them, and understand that without hurt to their own interests they may and should be loyal to efficient architects and builders of the community. These bear the burden and heat of routine alterations, repairs and maintenance work, and should not be sacrificed when more important and profitable enterprises are offering in the home field.

Experiments conducted in the office of Henry S. Spackman during the last year show that the addition of hydrated lime (about 10% by weight) to concrete and mortar is generally advantageous when the concrete is exposed to air or fresh water.

Concrete mixed with hydrated lime is more impermeable and shows less change in volume with changing moisture conditions than plain concrete.

Precautions Necessary to Assure Successful Concrete Work in Winter

With the winter months close upon us, with business conditions improving, insuring a greater demand for construction work, a resumé of approved cold weather construction methods seems timely.[1]

Repeated experiments have shown that when concrete is placed at a low temperature, so that the cement does not take its initial set quickly, it hardens very slowly. Instances are on record where a story in a concrete building poured at low but not freezing temperature required forms left in place for some time after the forms from the story above, poured in freezing weather, but with heated concrete, were removed.

Two methods of preventing freezing are in general use.

1—The addition of some substance that will lower the freezing point of the concrete.

2—Heating concrete materials and keeping the work warm..

The application of the first method is limited to weather not decidedly severe and is generally accomplished by adding common salt to the mixing water, although calcium chloride is sometimes used. According to Gillette & Hill,[2] salt retards the set and reduces the strength at short periods but does not, when used in moderate amounts, affect the ultimate strength. 1% of salt by weight of the water to each degree below freezing, with a limit of 10%, is a safe rule, but in no case is salt effective below 22° F.

Salt is objectionable for the following reasons: It retards set; it is likely to cause a disagreeable efflorescence; it is likely to cause corrosion of reinforcing metal.

The Trussed Soncrete Steel Co.,[3] has issued a placard to be tacked upon the job, outlining cold weather precautions in bold type.

Commercial preparations, (a recent one is described elsewhere in this issue), have been placed on the market which are claimed to prevent freezing without the undesirable effects of salt.

HEATING CONCRETE MATERIALS

Heating of concrete materials, proper protection of the work and eternal vigilance are the secrets of successful concrete construction in winter.

Heating Water — In moderate weather hot water will heat the other materials sufficiently. In small work, water may be heated in a large kettle or pan or by means of a coil made of sections of iron pipe. By far the best and in fact the only practical way of heating water for large operations is by live steam from the boiler, commonly applied as a jet in the barrel or tank holding the supply of mixing water.

The water should be as hot as possible up to 130°. High steam pressure is much more effective and economical for heating water than a comparatively low pressure.

Heating the Aggregate—At lower temperatures the aggregate must be heated and various methods are available. On small operations an old section of steel pipe is often used as a furnace, the aggregate being piled over it; in a similar way an old boiler or a sheet of steel bent in a U shape can be used where available.

A method which is preferable when steam is available is to make a steam coil with holes drilled in the pipe at intervals so as to allow the escape of steam. The material piled on this coil is quickly and evenly heated. A variation of this method is to attach perforated pipes to the boiler with steam hose and push them into the pile. While less efficient this method can be employed to advantage where material is in cars, bins, etc.

Live steam is often turned into the mixer to keep the mixer and concrete thoroughly warm.

FORMS AND STEEL

Forms should be made with exceptional care as they are to remain in place longer than in warm weather. They should be so constructed that side forms can be removed, the bottom forms remaining in place as long as needed. Shores should be located with reference to other work so they need not be disturbed and when possible should carry the load to the foundation with as little dependence on the concrete structure as possible. All forms should be free from snow and ice. A steam jet will clean and warm them quickly.

Reinforcing should not be frosty when concrete is placed, as even with warmed concrete a film of ice is likely to form on the steel that will prevent or injure the bond.

PROTECTING THE CONCRETE

Methods of protecting the concrete when placed must be varied according to the nature and size of the job. Small work can be protected by coverings of hay, manure, canvas, etc.

Forms offer sufficient protection to work when enclosed in them in comparatively mild weather. Where the character of the form work permits, building paper can be placed over them on 1-in. furring strips and is very effective. Certain kinds of hollow work can be cured by covering with canvas and turning steam into the enclosed space. On street railway work, electric car heaters placed under canvas have been used with success. Hollow wall construction can be cured rapidly by covering the top of the wall with tar paper and turning steam into the hollow space.[2]

Circumstances will sometimes warrant enclosing an entire job with a large tent or by means of a structure consisting of a light framework enclosed with frames covered with heavy building paper. Heat from salamanders or a steam plant makes safe work within an enclosure.

STANDARD PRACTICE ON BUILDING

The large number of reinforced concrete buildings erected in cold weather within the last few years has resulted in methods becoming well standardized and readily available.[3] Summarized briefly, they are,—heating materials, enclosing the stories on which work is progressing with canvas, heating the building, generally by means of salamanders.

When pouring each day's work, 6-in. cubes of concrete should be cast and stored in the coldest part of the building. Forms should not be removed before these cubes have reached a crushing strength of 1,000 lbs. per sq. in. Extra care should be used not to overload floors, etc. When concrete has frozen or is suspected of being frozen, extreme care must be used. Frozen concrete will ring under a hammer and the hammer test is not a safe one. The concrete should be exposed to hot water or to the flame of a blow torch until no question of its condition remains. Shores should never be removed until it impossible to drive a 10d nail into the concrete.

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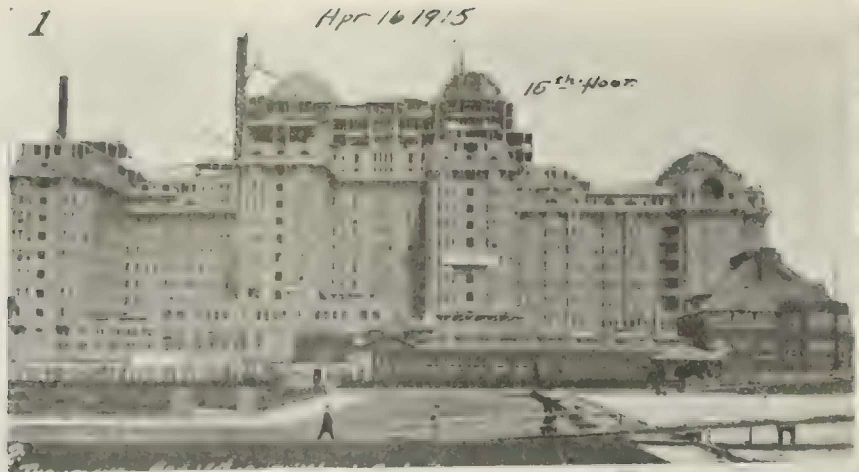
[1] Acknowledgement is made to the Universal Portland Cement Co., Chicago, whose Free Bulletin, *Concreting in Cold Weather*, has served in preparing this summary

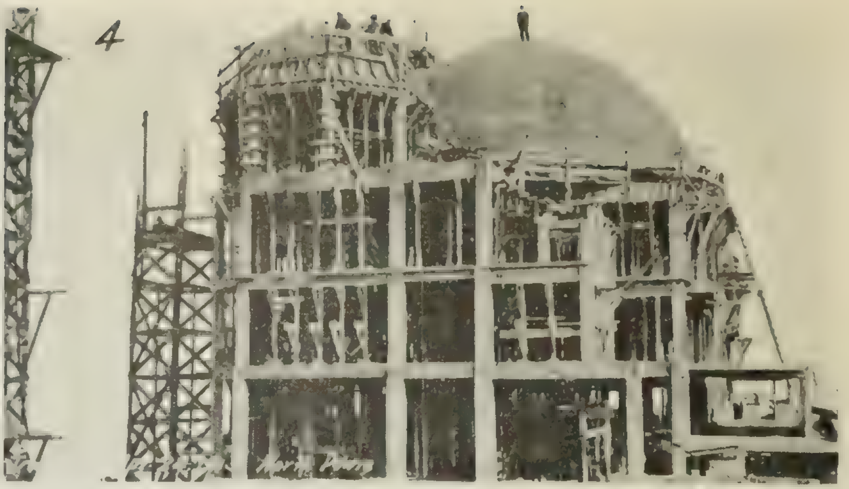
[2] *Concrete Construction Methods and Cost*

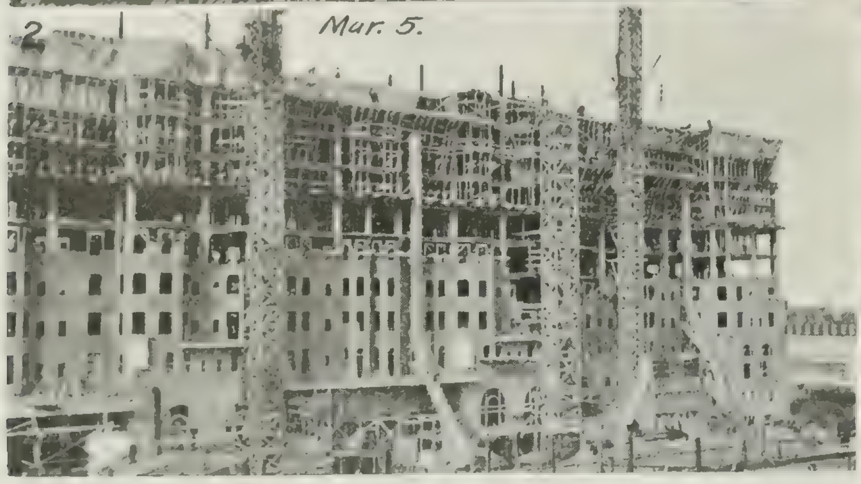
[3] Youngstown, Ohio

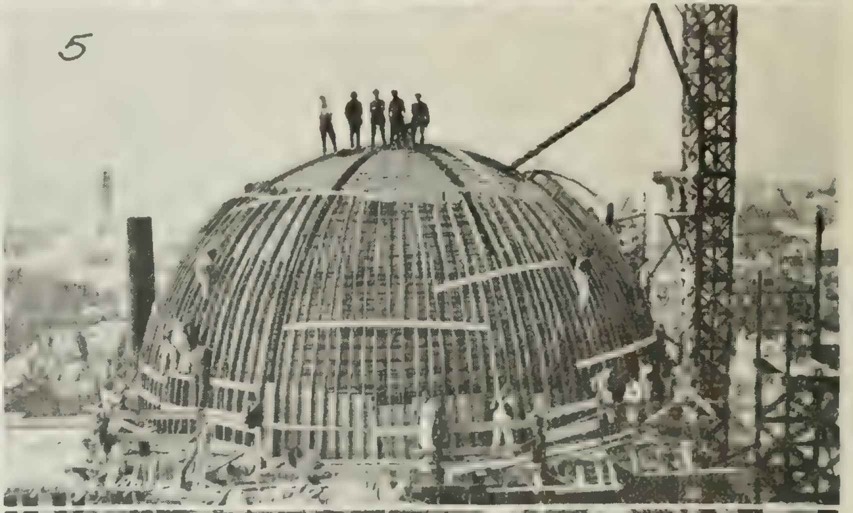
[2] See CONCRETE, Feb. 1914. p. 95

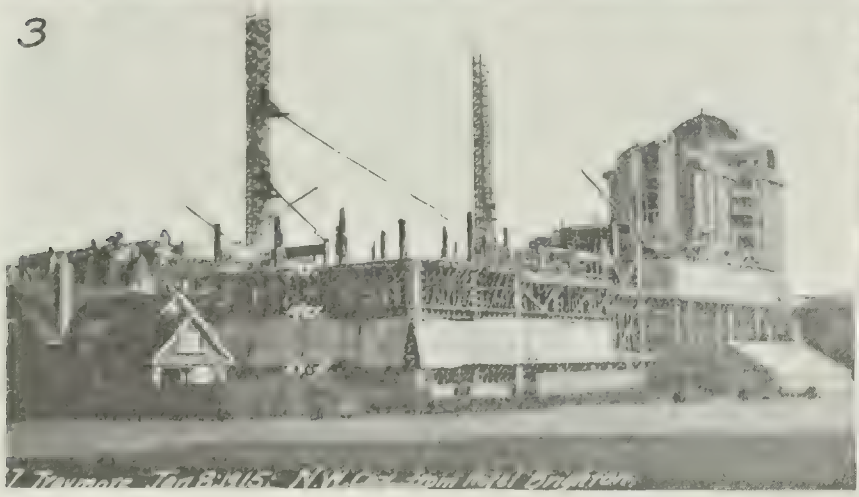
[3] *Concreting in Winter*, Free Bul. Assn. Am. Portland Cement Mfrs., Philadelphia











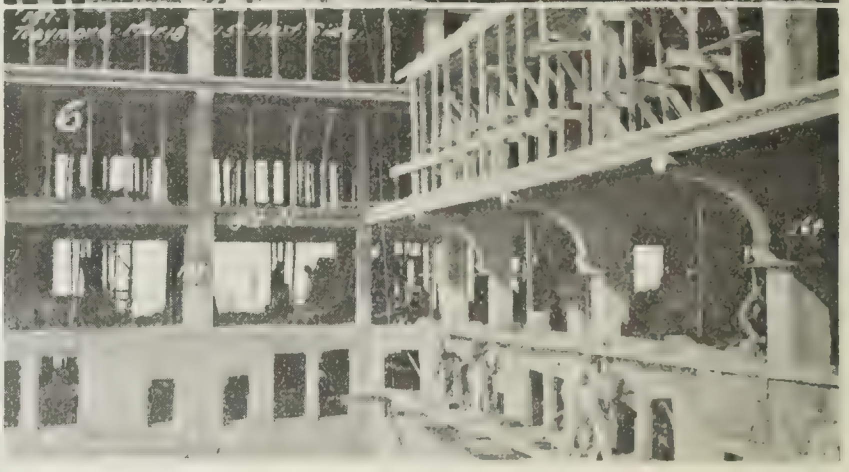


FIG. 1—ALL OF THE REINFORCED CONCRETE WORK IS DONE EXCEPT THE DOMES. NOTE HOW CLOSELY THE BRICKWORK FOLLOWS THE CONCRETE WORK

FIG. 2—EAST SIDE HOTEL TRAYMORE

Note the mixing plants, the towers for raising the concrete, the spouts and the booms on the side of towers for raising steel and lumber. The tower in the center is for the brickwork, and the chutes for the removal of rubbish. Note also the canvas protection for the concrete that is being poured; in all these spaces salamanders were kept burning until the concrete had set. Note also the steel forms for columns; these forms were erected on the forms so that they always show standing above the floor that is being poured

FIG. 3—BUILDING ENCLOSED WITH CANVAS

Old building is in background

FIG. 4—NORTH DOME

Note the completed dome with centering removed, also the centering for the small dome over the fire tower. Note, too, how the columns change centers, and the projecting slab on the outside of the lintels, to support the brick and the wall

FIG. 5—DETAIL OF DOME

Note inside and outside forms and reinforcing

FIG. 6—DETAIL OF 8TH FLOOR, SHOWING REINFORCED CONCRETE BALCONY

Cold Weather Construction Methods Used in Erecting Hotel Traymore

BY D. L. KNEEDLER[1]

The new Hotel Traymore recently completed at Atlantic City, N. J., is the largest fireproof resort hotel in the world. It has a floor area of over 470,000 sq. ft. and is 18 stories high, the top of the domes being 238′ above the sidewalk. The old building, seen at the right, Fig. 3, consisted of a 12-story reinforced concrete tower faced with terra cotta at the board walk end of the lot and a low frame structure in the rear. The work included certain changes and additions to the existing tower, and the erection of an entire new building on the site of the old frame structure, both parts of the work being done at the same time. While the building is unusually large and complicated in detail, the more remarkable part of the work is the speed with which it was done, considering that it was carried on throughout the winter without stopping for freezing weather.

The site was cleared and ready for the builders Sept. 1, 1914, and the hotel was opened for guests June 1, 1915.

Practically all of the reinforced concrete work was done between Dec. 24, 1914, and Apr. 24, 1915. This involved the mixing and placing of over 18,000 cu. yds. of concrete,

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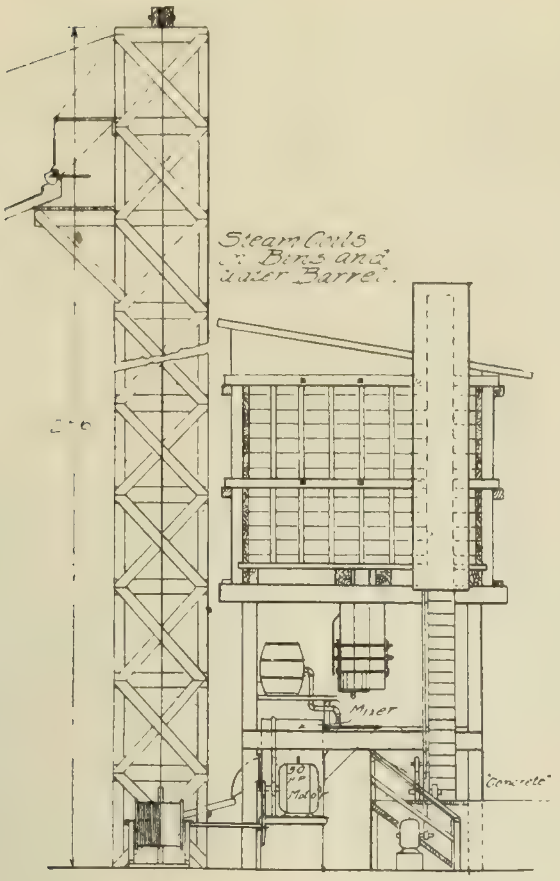
[1] Cramp & Co., Phila.



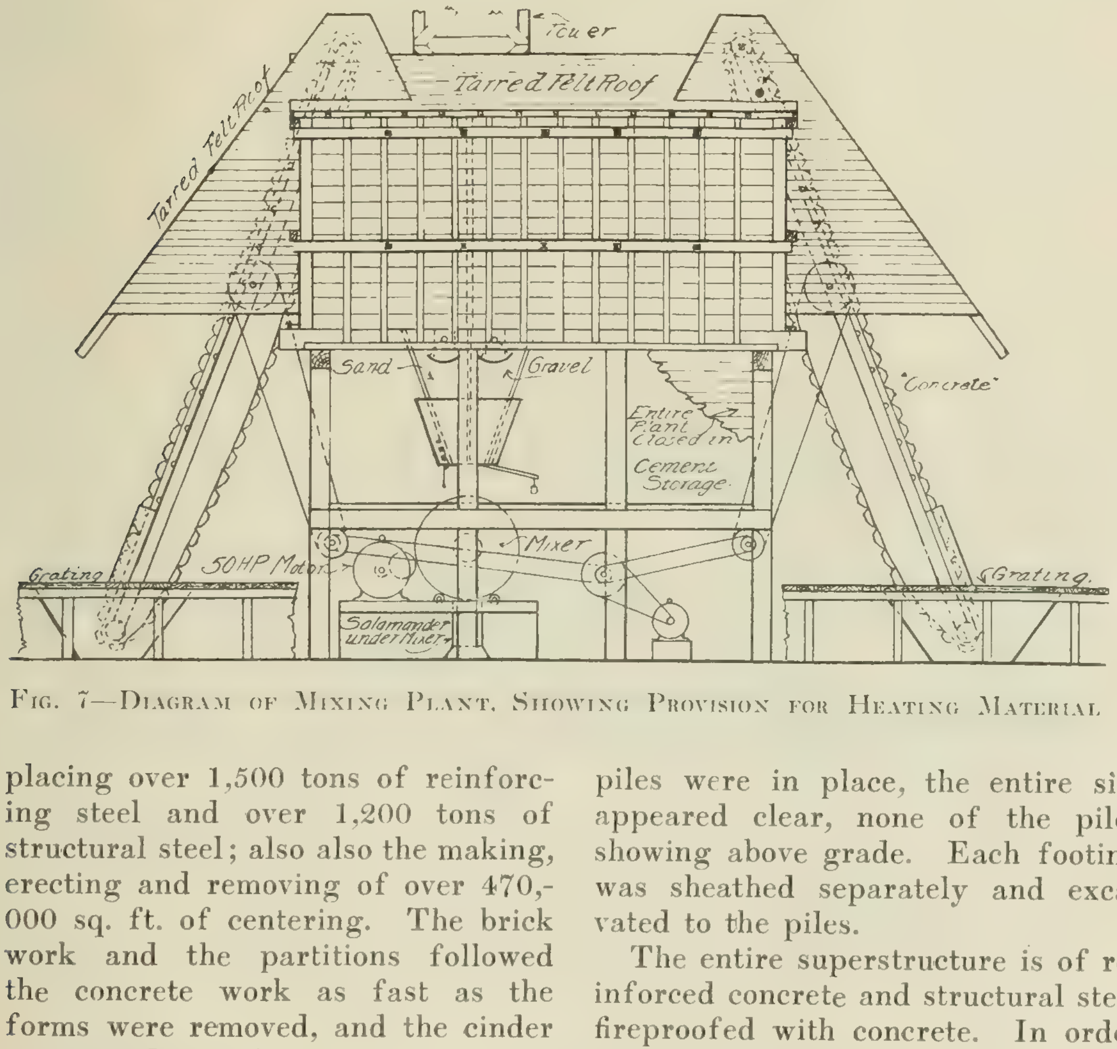


Fig. 7—Diagram of Mixing Plant, Showing Provision for Heating Material

placing over 1,500 tons of reinforcing steel and over 1,200 tons of structural steel; also also the making, erecting and removing of over 470,000 sq. ft. of centering. The brick work and the partitions followed the concrete work as fast as the forms were removed, and the cinder concrete floor fill and concrete floor finish followed in turn.

The centering was particularly difficult as the floors were not typical, but with the exception of the third to the seventh sleeping floors, they changed at every floor, requiring the forms to be remade entirely. Over 1,500,000 ft. B. M. of lumber was used in making the forms. The curved forms for the domes and for the brackets under cantilevered balconies and other special work were made in a planing mill.

The building occupies the entire lot, and faces on one street only, which is not only narrow but is blocked at one end by the ocean and the board walk, so that there was little room to store materials at the site. A large storage yard was taken adjoining to the railroad where a cement shed was built, and where the reinforcing steel and structural steel were stored and sorted, to be taken to the site as required. The sand and gravel were stored in large bins at the yard and hauled to the site in motor trucks. Being in bins allowed this material to be loaded very quickly by means of gates.

GENERAL CONSTRUCTION

The foundations are of reinforced concrete resting on wood piles. The entire lot was first graded down to about 4′ below the sidewalk or about high water line. The piles were then placed by means of a water jet, a follower being used to sink them to the proper elevation to receive the column footings, so that after all the piles were in place, the entire site appeared clear, none of the piles showing above grade. Each footing was sheathed separately and excavated to the piles.

The entire superstructure is of reinforced concrete and structural steel fireproofed with concrete. In order to accommodate the structure to the various architectural features, all kinds of concrete construction were used. In general the type of construction is solid slabs, with beams, girders and columns of concrete, but where large flat panels were required in the ceilings the combination of concrete joists and terra cotta tile fillers was used. Structural steel cores were used to keep down the size of heavily loaded columns and structural steel girders were used, where girders carried heavy concentrations, due to offsets in the column layout.

All the floors are finished in concrete over a 2-in. cinder concrete fill, and after the reinforced work was well advanced, one plant was used for this work only.

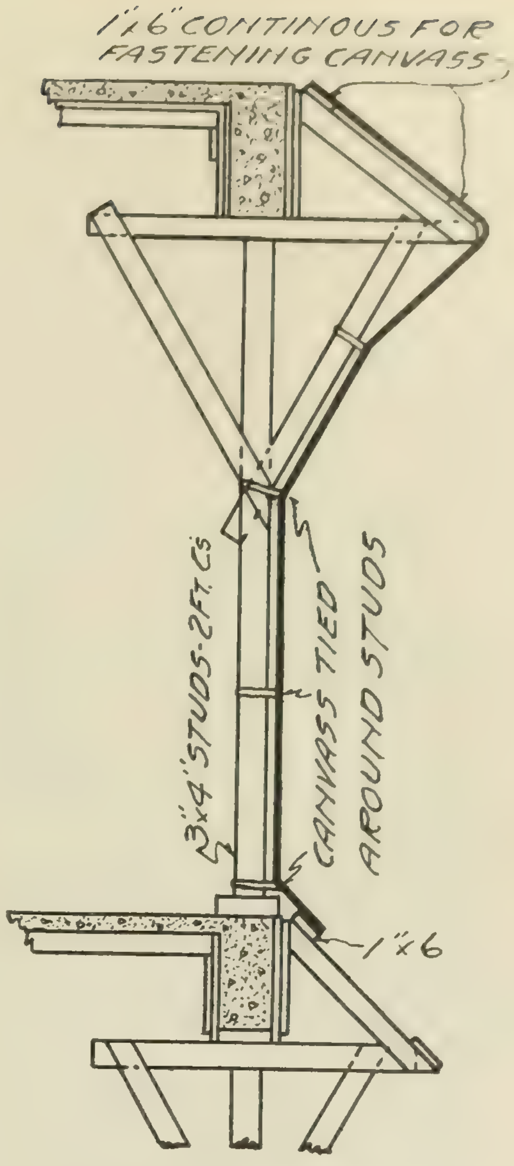

1"x6" CONTINOUS FOR FASTENING CANVASS
3"x4" STUDS-2FT. CS
CANVASS TIED AROUND STUDS
1"x6"

Fig. 8—Detail of Canvas Housing

CONCRETE PLANT

There were two mixing plants at the building, the details of which are shown in Fig. 7. The motor trucks ran up an incline onto a plank platform and deposited the materials through iron grates in the floor into hoppers, from which they were raised by bucket conveyors[1] to the bins over the mixer. Directly beneath the bins were the measuring hoppers loaded by means of gates as shown, and directly beneath the measuring hoppers was the mixer,[2] 1 cu. yd. capacity driven by a 50-h. p. electric motor which also operated the hoist.

The hoppers were quickly loaded by means of iron gates in the bottoms of the bins and as they were graduated the charge was accurately measured. In the bottom of the hopper was a gate held shut by a spring latch; by pulling a line the charge was deposited in the mixer. This gate was counterbalanced so that when the hopper was empty it closed itself. The cement was put in from the platform where the hoppers were filled; the water barrel was also on this platform. The barrel was accurately gauged to insure the proper quantity of water for each batch.

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[1] Good Roads Machy. Co., Kennett Sq., Pa.

[2] Ransome Concrete Machy. Co., Dunellen, N. J.

The towers for raising the concrete were 260′ high, 6′ x 8′ in plan, and had to be exceptionally well braced on account of the severe storms at the sea shore. From the towers the concrete was spouted[3] into place where possible, but for some of the longer distances on the upper floors it was spouted as far as possible into a storage hopper and wheeled the rest of the way in buggies.

HEATING AND PROTECTING CONCRETE

As will be seen by a study of Fig. 7, the mixing plant was designed with special reference to the extreme weather conditions under which the work was carried out. The gravel from the storage yards was dumped on the platforms and at once carried to the covered bins by bucket elevators which were themselves housed as shown. The bins were lined with steam coils on all sides, insuring a steady supply of heated aggregate. A steam coil is also used in the water barrel. It will be noted, too, that a salamander is located under the mixer to prevent loss of heat while mixing.

Figs. 2 and 3 show portions of the building enclosed with canvas and at Fig. 8 is shown a detail of the method by which the canvas was securely held in place. Each story was entirely enclosed as poured and salamanders were kept burning below each floor; the concrete as poured was at once covered with a heavy layer of salt hay, which remained till the concrete was thoroughly set. Work was carried on continuously day and night throughout the winter but the precautions described were effectual and no frozen concrete resulted.

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[3] Insley Mfg. Co., Indianapolis, Ind.

Casting Concrete Pipe Out of Doors in Winter at Hamilton, Ontario

By Andrew F. Macallum, C. E.[1]

Since 1909 all sewers in Hamilton, Ont., larger than 24″ in diam, have been constructed either of reinforced concrete or of sectional concrete pipe. In the winter of 1914-1915 in order to give work to the unemployed because of conditions caused by the war, we constructed in the east end of the city a trunk sewer system, using reinforced concrete pipe from 30″ to 66″ in size. These pipe were made in an open field during nearly all conditions of winter weather and cured by means of steam, from pipes running under the molds and with canvas tarpaulins over the pipe. Rejections of pipe under these conditions were not greater than would have been the case under good working conditions of the summer season.

These pipe were made on contract by A. L. McAllister, Toronto, who rented forms for the work[2] from the Chicago Concrete Pipe Co. A 20-h. p. portable boiler was hauled to the curing ground and a shed built around it for shelter. Two-in. galvanized pipe were laid along the ground in three parallel lines with T connections and stop cocks at 10-ft. centers. These pipe connections were directly beneath each pipe that was cast. The mixture was brought alongside the mold that was to be filled and hot sand, gravel and water were used. Just as soon as a mold was filed burlap was placed over it and a long canvas tarpaulin, 10′ wide and 100′ long, covering a series of these casts, was placed on top of the burlap. Steam was turned into the interior of the molds and kept on continuously night and day until the pipe had hardened. We also laid last winter some rectangular sewer, 6′ x 8′, in section having the span of 8′, and dry weather half channel in the bottom.

The materials were mixed hot and covered over with canvas tarpaulins until sufficiently set, when fresh manure to the depth of 1′ was placed on top and salamanders inside. This worked out in a very satisfactory manner and we had no failure whatever with any part of the work.

In connection with handling the pipe: the 54-in. pipe was used on a street having an electric railway track not in use. It was rolled onto flat cars, hauled to position and by means of block and tackle with rope around the pipe allowed to run slowly down skids to the ground.

The 66-in. pipe was teamed on sleighs to its position. Both sizes were lowered into trench with overhead frame and Yale blocks, using goose-neck to lower and place the pipe.

Two Views Showing Outdoor Manufacture of Concrete Pipe in Winter

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[1] City Engr., Hamilton, Ont.

[2] Chicago Concrete Pipe Co., formerly Michigan Lock Joint Pipe Co.

Field Methods in Concrete Construction—Cleaning and Lubrication of Forms and Centering

By Jerome Cochran, C. E.[1]

The series of articles on field methods in concrete construction, of which this is the eighth, has been planned in opposition to the general assumption on the part of writers that standards or methods of construction have been established long ago and have become common knowledge. The first article on "Selection of Concrete Materials" appeared in this magazine for Jan., 1915; the second article on "Proportioning and Mixing Concrete" appeared in Feb., 1915; the third article on "Design and Construction of Forms in General" appeared in Mar., 1915; the fourth article on "Column Forms" appeared in Apr., 1915; the fifth article on "Beam and Slab Forms" appeared in June, 1915; the sixth article on "Wall Forms" appeared in July, 1915, and the seventh article on "Arch Centers for Concrete Bridges" appeared in Sept., 1915. The following article relates to the cleaning and lubrication of forms and centering in general. In preparing this material the author has drawn liberally on his book, Inspection of Concrete Construction.[2]

CLEANING FORMS IN GENERAL

A procedure of far-reaching importance in concrete construction which cannot be too much insisted upon, being no less important than proper concrete, but which appears like a useless refinement to most untrained foremen and laborers, consists in cleaning forms of the usual dirt and debris in order that no shavings or ends of boards find their way into the concrete. This precaution, particularly important with forms for columns, girders, beams and floors of buildings and bridges, constantly makes the difference between good work and that which is bad or even dangerous, as sawdust, shavings, small wooden blocks, dirt, ice and other foreign matter in a loosely connected mass do not make a fit substitute for first-class concrete. Failure properly to look after this cleaning damages the work in a way which is hard to rectify, as a comparatively small amount of debris breaking the continuity of the concrete in a column or beam may largely reduce its carrying capacity.

All forms must be absolutely clean and free from shavings or foreign matter, as well as dry mortar left on the forms during the previous day's work, before beginning to deposit concrete. It is a simple matter to keep the forms clean and free from such accumulations. A very unsightly face is frequently produced by leaving the mortar on the forms, which has resulted by the throwing of concrete into the forms in the previous day's work. The writer has seen some otherwise excellent work thus soiled, especially where the surface finish of the structures was the most important part of its design and construction.

Loose hand-hole caps or small removable panels are usually provided at the bases of all columns and wall forms, as well as deep beams and girders, sufficiently large to gain access to the inside of the form to remove sawdust and other materials that collect in the forms. It is not sufficient to inspect and clean out the foot of the forms just before pouring concrete, but the inspector or foreman should look through the opening and see that no refuse of any kind has fallen into the box and become lodged in the reinforcing steel. Sweepings from girder boxes are very likely to find their way to the column forms and care must be taken to see that the bottoms of column forms are thoroughly clean just previous to placing the concrete.

The concrete gang and not carpenters should be used in removing dirt, shavings, etc., from forms, care being taken that no dirt falls into fresh concrete while cleaning forms. A section which is to be concreted should be cleaned up only a few minutes ahead of the time when the concreting is to begin—a point that is often overlooked by workmen. This precaution prevents the possibility of debris collecting in forms a second time, as the cleaning is done just previous to placing the concrete.

Steam, compressed air or other effective means, especially in freezing weather, should be used when possible for cleaning dirt and sawdust out of forms. While compressed air has been used with great success for this purpose, yet steam from a hose connected to the steam boiler on the job will usually be found preferable, as it blows out the dirt and wets the forms at the same time. Steam is also useful in freezing weather in removing snow and ice from forms and steel reinforcement. In this way any particles of ice are melted and the chill taken off the forms and reinforcing steel. Boiling water may also be used with good results in thawing out frost, which has a tendency to make the concrete adhere to the forms. Sawdust and other foreign material can be removed with a hose from the steel and from the form sides.

CLEANING FORMS AFTER REMOVAL

All forms having been previously used should be thoroughly cleaned immediately after being taken down and properly prepared before being used again, especially where a smooth, firm face is desired on the concrete work. After the old forms have been brushed as clean as possible with stiff wire brushes or short-handled hoes to remove all loose material, they may then be gone over with a steam jet under high pressure. The steam should be directed against the forms until the concrete adhering to them softens, when it may readily be scraped off. If the job is not large enough to justify using a steam jet, then use wire brushes or hoes and plenty of elbow grease, following with water applied through a hose with considerable pressure.

Do not hesitate to use a hose freely for cleaning purposes. Care must be taken not to gouge the wood in using hose when cleaning off bits of concrete clinging to old forms.

Molds for ornamental concrete must be kept perfectly clean, thus making a clear-cut impression each time. They should be wiped frequently with an oiled cloth to keep them clean and smooth, care being taken not to discolor the face of the cast by using too much or too dirty oil.

ADHESION OF CONCRETE TO FORMS

Concrete surfaces are frequently impaired by the adhesion of the surface to forms where no special provision is taken to prevent it, and a considerable force is often necessary to separate the forms from the concrete. Where this adherence takes place some of the surface of the concrete comes off, and the lumber has to be scraped before it can be used again. The concrete surface has a rough, unpleasing appearance and has to be patched up with a trowel, or "made good," as this operation is called.

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[1] Cons. and Cont'g. Engr., Houston, Tex.

[2] Myron C. Clark Pub. Co., Chicago

Many different methods are employed to prevent concrete from sticking to the forms. If the lumber is planed, the smooth surface will reduce the labor of removing and cleaning the forms, the concrete being much less likely to stick. Even if the appearance of the concrete is of no account, it is generally best to use lumber for sheathing that is dressed on at least one side and two edges. The finish of the concrete surface is improved and the lumber left in better shape to use again, if the forms are coated with some substance to close the pores in the wood, as less concrete sticks to it.

COATING OF FORMS

All forms for concrete require a coating of some lubricant to prevent the concrete from adhering to the surface of the form with which it comes in contact, thus causing large areas of concrete to be pulled off with the forms where wet concrete is poured against dry forms. This is especially true for very particular work, or where forms are to be used more than once.

The coating of molds for newels, finials, rails, balusters, spindles, balls, caps and bases for piers, as well as other ornamental concrete work must insure their parting from the cast without adhering in the least, otherwise small particles will be broken or scale from the surface, requiring much labor to repair. This coating must be of some material that will form a non-adhesive film over the face of the mold, thus insuring clean partings between mold and cast.

Coating the forms with crude oil, soft soap or other greasy materials to prevent adhesion of concrete to the forms, not only tends to give a smoother surface to the concrete and to preserve the wood against damage by its alternate wetting and drying, but also serves to prevent the marking of the grain of the wooden forms on the finished concrete work. Where concrete surfaces are to be whitewashed, grouted or plastered, the forms should be thoroughly wet before placing the concrete, instead of being oiled or greased, as the oil or grease is very apt either to discolor or to prevent the adhesion of the whitewash or the plaster.

It is not unusual to coat metal forms with either tallow or bacon fat, which seems to give the best results with forms of this material, while wooden forms are sometimes given a good soaking with ordinary soapy water. In fact, cheap soap boiled and applied hot gives very good results in preventing the adhesion of concrete to forms or ornamental molds. Wooden forms have also been covered on the inside with building paper, and even canvas has been used, although it is usually found that unless the paper is very oily it will adhere to the concrete or that it is almost impossible to keep the paper absolutely smooth so that the final surface does not show wrinkles. The use of these materials, as well as additional coatings for forms, will be taken up and discussed elsewhere in this article.

When wooden forms are not to be removed for several weeks or until the concrete has become hard, the cohesion of the concrete will be greater than its adhesion to the wood, and the concrete will not as a general rule adhere seriously if the forms are simply wet thoroughly with water just before the concrete comes against them, no oil, grease or soap being necessary.

WETTING OF FORMS

Except in freezing weather, all forms, if not coated with some oil, soap or greasy materials, should be thoroughly drenched with water before depositing concrete or mortar facing. This is of value in preventing the wood from absorbing too much moisture from the concrete that is placed next to the form. In other words, wetting the forms prevents them from absorbing water from the concrete, which it requires for setting and hardening, and there is not much danger of concrete adhering, especially if the wood is thoroughly wet with water before the concrete is laid.

In very warm, sunny weather, forms should be kept constantly wet to prevent excess shrinkage and warping, by making the forms swell and thus close the joints and prevent leaking. The hose should be applied thoroughly to both sides of the forms until the boards take up no more moisture, as a sprinkling of the inside with a hose is not usually sufficient. *When dry spots appear, wet them.* In freezing weather, steam should be used in place of water to drench the forms, just before placing the concrete.

It is not always possible thoroughly to wet the forms, and frequently it is impossible to keep them wet without adding too much water to the concrete already poured and possibly injuring it. In other words, water is very likely to dry out during the filling of high wall forms, and more water cannot be added without thinning the concrete already poured. Where the water pressure is not sufficient to bring water to the upper stories of high buildings, a steam pump, driven by steam from the contractor's hoisting engine boiler, is often employed for the purpose.

OIL FOR FORMS

On work on which it is intended to remove wooden forms as soon as possible in order to finish the face of the concrete, the forms may be given a coat of light mineral oil (not animal oil, as the fatty acids it contains attack the concrete), so that the wood will not absorb the moisture from the concrete and thus cause the concrete to adhere. However, it is not absolutely necessary to oil forms, provided they are thoroughly wetted as previously suggested.

Oil aids in preventing the warping of wooden forms, as wood that is proof against moisture is less liable to check or warp than wood that is untreated. A slight oiling of forms will result in great economy in saving of forming lumber. An excess of oil must not be used.

The oils or water-resisting preparations commonly used for lubricating forms are crude oil (petroleum), paraffin (refined petroleum), asphaltum paint or varnish.

Crude oil, petroline or petroleum, cut down with three parts of hot kerosene and then applied to the surface of wooden forms with a large whitewash brush and allowed to penetrate until the wood takes up all of the oil that it will, makes one of the best coatings, but undiluted linseed oil, oil paint, and various compounds of a similar nature, as well as any grease that will spread evenly and fill the pores of the wood will answer equally well and may be employed for this purpose, the object being to fill the pores of the wood rather than to cover it with a film of grease. Dead oil, or crude petroleum is probably as economical as any oil that can be used for greasing forms. It is found that crude oil need be applied but once or twice, as it seems that the pores of the wood are filled, and also by cement, which prevents old forms from sticking to the concrete.

Linseed, black or cylinder oil is suitable, but kerosene is not good. A mixture of kerosene and vaseline, however, has been used and has been found particularly advantageous on exposed concrete surfaces. The kerosene acts as a thinner, and soaks into the wooden forms, leaving a thin coat of vaseline, which readily disappears on exposure to sun and weather, after the removal of the forms.

Forms which are to be used repeatedly may be given on the surface next to the concrete three good coats of pure boiled linseed oil, applied with a brush, and each coat allowed to dry before the forms are used. Boiled linseed oil gives a glazed or varnished surface to the forms. A compound of linseed oil and petroleum, mixed ⅓ petroleum to the volume of oil, may be painted over the surface of wooden forms.

Some drilling and lubricating compounds have also been used. They are greasy and do not dry quickly, and in this respect are better than soap. Hot paraffin is sometimes used.

A light-colored axle grease in one instance prevented steel forms from sticking to concrete, though ordinary black grease failed to give the desired results.

Fatty oils should not be used, as they act on fresh concrete by disintegrating and discoloring it. Glycerin leaves a fatty stain.

A transparent jelly, made by melting 1½ lbs. of paraffin in 10 qts. of kerosene oil and applied with a whitewash brush or with waste, makes the forms leave the concrete with little or no concrete adhering to them and at the same time does not stain the concrete, a film or coating of paraffin remaining on the surface of the forms while the kerosene evaporates to a certain extent.

Grain marks can be reduced to some extent by oiling the lumber with gloss oil and then throwing fine sand against the oiled surface with bellows:

Several objections are made to the use of oil for greasing forms, among them being the following: (1) The expense. (2) The handling of greasy forms. (3) The weight of oil-soaked forms in handling. (4) The liability of discoloring the face of the concrete. (5) The difficulty of properly treating surfaces which have come in contact with oiled forms. (6) The difficulty of securing an effective bond between new concrete and old concrete that has a thin film of oil or grease on its surface.

By not using a grease but an oil, like crude oil, which is a petroleum product, it will soak into the wood and the forms will not be too greasy to handle.

A light oil should be used where a possible stain on the concrete would be objectionable, as a dark oil shows up very conspicuously.

There is no question that the fifth objection is a very serious one, it being almost impossible to get rid of the thin oily coating, which often gets on the concrete from the forms, and to make plaster stick to an oiled surface. This almost invisible film of oil or grease is also very effective in preventing a bond of new to old concrete. For this reason it is better to use soap than oil or grease on the inside of forms when concrete surfaces are to be whitewashed, grouted or plastered, or a bond is to be made between new and old concrete, since soap is soluble in cold water and hence is easily washed off.

If the walls require plastering or any subsequent treatment, the oil skin, if any, must first be removed; or if so required by the specifications, the forms must not be oiled but instead must be thoroughly soaked with water as described above. Sometimes even oiled forms require wetting on hot days to prevent shrinkage.

OILING FORMS

Oiling of forms should be done by ordinary laborers and not by carpenters, as well as cleaning forms previous to lubricating them.

Do not use any preparation when the wall is to be plastered, as the oil would prevent plaster adhesion. Use unsurfaced lumber in this case, when practicable.

Forms must be perfectly dry before the oil coating is applied, otherwise the forms will not absorb enough oil to do any good. The number of coatings necessary will vary with the wood and also the condition of same at the time of treatment.

Oil thick and heavy enough to act as a filler should be used in oiling forms, care being taken not to get the oil on too thick; otherwise grease spots in concrete leave an unsightly appearance. The quality of oil known as "sludge" at the oil refineries, or its equal, is recommended. The oil should be thin enough to flow and fill the grain of the wood. In fact the requisite of any oil is that it shall be thin enough to spread evenly and to fill the pores and grain of the wood.

The oil must be thinned to the proper consistency as occasion demands and applied to forms, either by dipping or painting the lumber, or by painting the forms after they are set. Be very careful in the latter case not to allow any steel reinforcement to come in contact with the oil, as this destroys the bond between concrete and steel.

If at any time forms coated with boiled linseed oil become rough, and there is danger of injury to the smoothness or appearance of the concrete, they should be cleaned, redressed and given three coats of pure boiled linseed oil, applied with a brush, and each coat allowed to dry before the forms are used. The oil must be applied every time the forms are set. That is to say, when the forms are to be used again they must be thoroughly cleaned and re-coated with oil.

Molds for ornamental concrete, especially for concrete building blocks, must be kept perfectly clean, thus making a clear-cut impression each time. They should be wiped frequently with an oiled cloth to keep them smooth and prevent sticking. Care must be taken not to discolor the face of the cast or block by using too much or too dirty oil. If the molds are not properly cleaned and oiled, it will be impossible to release the blocks without cracking or chipping them. Not much time is required in cleaning and oiling, and if the work is carefully done (as it should be), the result will be a much better and much larger product than if the molds are neglected.

SOAPING FORMS

Ordinary soft soap or soap oil, thoroughly dissolved in water to the consistency of very thin paste and applied hot with whitewash brushes or brooms, may be used instead of oil for lubricating forms when the inflammability of the oil is objectionable. The forms usually come away from the concrete as readily as when they are oiled or greased, as soapy water gives very good results in preventing the adhesion of concrete to forms when applied properly.

The use of soap does not injure the surface or diminish the strength of the concrete. On the other hand, it helps make a dense surface and should be used instead of oil or grease when the surfaces are to receive subsequent treatment, i. e., whitewash, grout or plaster. Its use does not interfere materially with such treatment, provided the surface of the concrete is well washed with clean water before applying the whitewashing, plastering, etc. Being soluble in cold water, the soap is comparatively easily removed from the concrete surface, while oil or grease used on forms is very apt to discolor the whitewashing or plastering, unless all traces of the oil or grease are removed from the concrete surfaces.

In using soap, the forms are simply given a good soaking with hot soapy water, applied with whitewash brushes or brooms, some little time before the concrete is run, and the forms should always be scraped and brushed when taken down. Soap oil can usually be purchased from the nearest soap factory.

The objections to the use of soap are that it is expensive and that it is seldom applied properly.

WHITEWASHING FORMS

Common whitewash, when made properly and properly applied, may be used instead of soap or oil for coating forms, and will be found very efficient in preventing adhesion of concrete to forms. In fact, it is an excellent material for this purpose, and it would be difficult to find anything cheaper.

COLD WATER PAINT

Compressed air spraying machines may be used for applying cold water paint to wooden forms, as well as whitewash. Care should be taken that the paint is applied fairly uniformly, depending upon the nature of the work, i. e., ornamental, mass or reinforced.

USE OF GLUE, LIME, PLASTER OF PARIS AND CEMENT

Forms may be coated with a compound consisting of glue, plaster of Paris and Portland cement, which not only covers the forms but fills the cracks as well, thus preserving the forms in good shape and assuring an extremely smooth surface to the concrete. The composition of the mixture is as follows: To about 1 lb. of cheap glue, dissolved in a pail of water, add a quart of lime putty, a pint of plaster of Paris and, when these are thoroughly mixed, enough Portland cement to give the desired body to the mixture. Natural cement may be substituted for the Portland, and will be found more economical. This mixture is more effective when applied a short time before concreting, as it dries out rather quickly. Large cracks in forms may be filled by thickening the mixture with more cement.

USE OF SHELLAC

Plastic molds for ornamental concrete, such as plaster, plaster compositions, etc., may be coated with shellac, to give them a smooth and moisture-proof surface, after which they should be coated with oil having a thick body or where the molds are made up of small sections the surface of each plaster section, after being coated with shellac and allowed to dry, may be dropped into melted paraffin wax.

Crude petroleum and also heavy machine oil may be used instead of the paraffin, as well as vaseline, axle grease or hog's lard. The concrete surface is not ordinarily injured by an oil coating, unless it contains certain mineral coloring matter. The oil coating is absorbed into the pores of the concrete in drying or hardening, and may be removed from the surface when the object is subjected to such surface treatments as scrubbing with wire brushes, carborundum stone or dilute hydrochloric and sulphuric acid. Concrete surfaces may also be removed by tooling with pneumatic tools or by hand, as well as by sand-blasting.

The film of paraffin formed over a mold or section of mold when dropped into melted paraffin wax is absolutely non-absorbent, making it positive that the concrete or mortar facing cannot stick to the mold. In order to insure the mold or sections of the mold drawing perfectly, the paraffin should be applied after each casting.

Fine stone dust may be blown on the varnished surface of forms before it has dried, thus causing the markings of the grain of the wood on the cast concrete to be scarcely noticeable and, at the same time, allowing the forms to be easily removed.

Shellac, applied to the end grain of form lumber in contact with concrete, prevents the absorption of water.

USE OF ENAMEL

Molds for ornamental concrete may be coated with a bath-tub enamel or any enamel coating that is proof against moisture. The enamel should be laid with a soft brush and not allowed to run, otherwise it will not produce a smooth and even surface coating. The smooth and glossy surface produced on a concrete cast is similar to that produced by molding over sheets of glass as a molding surface. Metal molds may be prevented from sticking by baking the enamel on so as to produce a durable coating.

USE OF POWDERED CHALK

Powdered chalk, mixed with water to the consistency of thick cream and applied with a brush, will be found very useful for ornamental metal molds or upon any surface that is smooth, as it is not injurious to the concrete and can be easily removed by washing the cast with water. Such a coating tends to lighten the surface of the concrete, but is not permanent.

USE OF FINE SAND

For ornamental work cast face down, the wet mortar or concrete may be placed upon the top of a thin layer of a mixture of fine sand and Portland or natural cement (about 1/8″) sifted onto the face plate or bottom of mold, and tamped or puddled. The dry material will take up the surplus moisture upon the face of the cast, thus preventing the mold from sticking any more than damp sand would adhere to the mold. The dry material becomes a part of the cast, due to the fact that it bonds with the wet mortar or concrete placed upon it. Fine sand may also be thrown with a bellows against forms oiled with gloss oil.

LINING FORMS WITH SHEET METAL

Galvanized sheet iron is preferable to black iron for the lining of forms, because the concrete adheres more strongly to black plate than to galvanized iron, and, besides, the plate is liable to rust and stain the work. In either case, the adhesion of concrete to forms lined with sheet metal is generally more difficult to overcome, as ordinary oils will not adhere properly to the lining; fat salt pork has been found to give satisfactory results.

LINING FORMS WITH PAPER

Forms are sometimes covered with resin-sized sheathing paper lapped 1″ at joints and tacked in place, but it is somewhat difficult to keep the paper absolutely smooth, so that the final surface does not show wrinkles. The paper is easily torn in placing reinforcing steel and in shifting the forms, requiring constant attention in order to secure satisfactory results. Paper swells when damp and sticks to the concrete surface when the cement sets, and will usually adhere very strongly to the concrete, thus making it almost impossible to remove it. Unless the paper is very oily, it will be necessary to burn or soak it off so as to effect its removal; generally the former, as a thorough soaking very seldom removes the paper entirely.

LINING FORMS WITH CANVAS

While the writer has never seen canvas painted with linseed oil used as a cover for rough forms, yet he has heard of it being recommended for such purpose. It is claimed to be economical for the reason that it could no doubt be used repeatedly and it does not require planed boards in the forms. It would prevent the leakage of the liquid mortar that occurs at cracks or joints in forms, and being waterproof it would not absorb water from the concrete. It would further help to keep the frost out of the concrete. Forms have been made with open joints and afterwards covered with canvas, which absorbed the excess of water and gave a uniform surface finish to the concrete.

Testing Concrete and Aggregates — Laboratory and Field Methods

By R. E. Goodwin[1]

The present day finds engineers more willing than ever before to admit limitations to their knowledge of concrete, and a new conservatism is replacing the previous assurance in regard to its use. Factors which have brought this about are cases of disintegration of concrete from sea-water, electrolysis and other causes; field tests which show its variability under field conditions, the discovery of wide variations due to differences in aggregates, the uncertainty connected with problems of waterproofing, criticism of accepted standards of design, and other causes brought into prominence by investigation and experience. It may safely be said that the whole practice of design in concrete is in a state of transition and important changes are certain to be adopted from time to time as new information becomes available.

On account of the uncertain factors affecting its use, special precautions are being observed in the construction of the immense new subway system for New York City to make all concrete of satisfactory quality. In addition to the testing of cement as regularly practiced on all important works at the present time, these precautions include inspection and tests of all aggregates previous to their use, and field tests of concrete. In order to handle this part of the work the Public Service Commission, which is in charge of subway construction, maintains a special laboratory and special inspectors. Some of these inspectors are stationed at stone-crushing and gravel-screening plants, and are required to obtain for the work aggregates which will conform to reasonable practical specifications for grading and cleanliness. Other inspectors devote their time to making field test specimens from concrete mixed on the work.

The character of this inspection is something new in engineering and the scale of it is large, both of which facts lend interest to a description of the methods used and of the results accomplished. Such a description is especially appropriate at this time when the technical societies are beginning to undertake tests with a view to recommending standard methods for testing concrete and concrete aggregates.

The subject naturally divides itself into the following parts:

Fine Aggregates, Coarse Aggregates, Concrete and Miscellaneous.—Of these the field which promises to be the most fruitful for the investigator is the study of fine aggregates.

TESTING FINE AGGREGATES

Sand alone is used for fine aggregate on the work here described. Of this the greater part is washed Long Island sand of excellent quality and grading, furnished by large plants elaborately equipped for screening and washing sand and gravel. Some plants go so far as to screen sand into different sizes, which are remixed in proportions to suit the purchaser. Sand from these plants is tested daily for mechanical grading and silt, but is not regularly tested for tension nor compression in mortar. Some sand that is excavated on the work is used. This is always tested for compression in mortar as well as for mechanical grading and silt. The most frequent cause for failure of sand to pass the tests is excessive fineness. Fine sand will not make mortar nor concrete of satisfactory strength. For failure to be caused by foreign matter is an unusual occurrence. Nevertheless, modern theories and investigations into the nature of the setting of cement indicate that it is of such a character as to be vitally affected by foreign matter in quantities so small that laboratory methods are necessary for its detection; hence no sand of uncertain quality should be used without first demonstrating that mortar made from it will harden properly. The test in mortar is of the greatest possible value because it directly duplicates field conditions, so far as it is possible to do so in the laboratory. Compression specimens in the form of 2-in. cubes or 2-in. x 4-in. cylinders are very satisfactory, but tension briquettes require a less expensive machine for breaking and give good results also. Even when no testing machine is at hand some-

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[1] Junior Engr., in charge of Physical Testing Laboratory, Public Service Comm., N. Y. C.

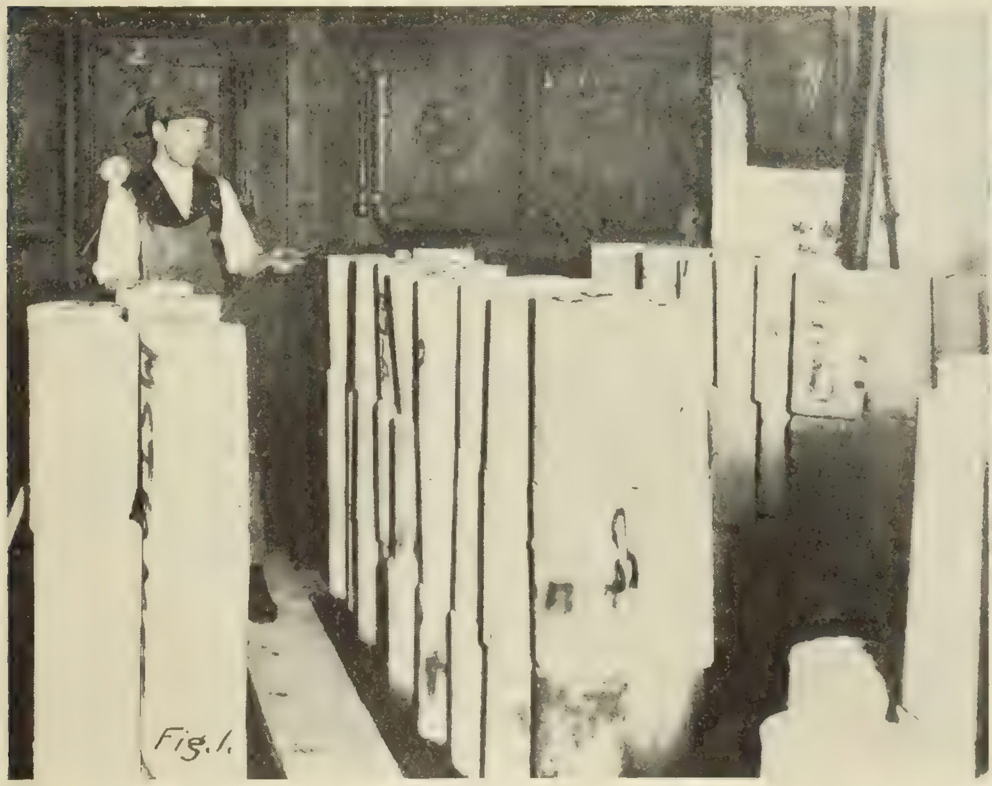

Fig. 1—Concrete Test Cylinders in Curing Room

Fig. 2—Making Test Cubes

thing may be learned by making the sand into mortar and observing whether or not the latter hardens normally. All specimens should be made of wet consistency in order to duplicate field conditions. Specimens of Ottawa sand made under similar conditions are used for comparison. The few comparative tests that are available seem to indicate that a wet consistency is a more severe test for commercial sands than normal consistency, and that the use of 2-in. x 4-in. cylinders is more severe than the use of 2-in. cubes.

It is desirable that the engineer's decision as to the fitness of sand for use in concrete should be based on the results of 28-da. tests in mortar, but when an early decision is required acceptance may safely be based on the results of 7-da. tests. A sand which fails to pass the 7-da. tests may prove to be acceptable after 28 das., especially if failure is due to fineness: for mortar and concrete harden more slowly when made from fine sand than when made from coarse sand, and approach the strength of the latter more nearly at the later ages than at the early ones.

Supplementary Field Tests for Sand.—The only reliable method of testing sand is its use in mortar specimens. However, there are one or two other tests which are valuable supplements to this one because they are quickly made and permit the engineer to form an opinion of the material soon after the sample is received. One of these is sieve analysis. A few strength tests of sands of different mechanical gradings in mortar are sufficient to indicate what minimum degree of fineness may be permitted without falling below the quality of Ottawa sand, and this limit of fineness will be of very great assistance in judging future samples. In judging samples no attention need be paid to sharpness, since the requirement that sand shall be sharp has been proved to be unnecessary and should be omitted from specifications.

Another valuable and quickly made test is the one for silt. This is quite commonly made by shaking the sand with water in a bottle and measuring the thickness of the layer of silt which settles after standing. But like many other unstudied methods the results of this proceeding are not of much value. If the silt is of a heavy mineral nature it will settle into a thin, compact layer, while if it is light and flocculent it will form a thick layer even though it has little substance. The writer was once required to test a sand which contained 25% of silt by volume when shaken up with water, but of which only 9% by weight could be washed through a No. 100 sieve. Two-in. cubes made from it in 1:2 and 1:3 proportions tested considerably higher than Ottawa sand. The results were considered so remarkable that an error was suspected until the tests had been repeated. The same results were obtained the second time. On the other hand some sands show less silt by the settling method than by washing. These results should show the incorrectness of the settling method. The proper method to use is to wash the sample on a No. 100 sieve under a stream of water, the per cent of silt being calculated from the loss in weight.

Another test which must be relegated to the same class as the settling test for silt is the very commonly used void test for proportioning concrete. The inaccuracy of this method is due to the variation in the amount of voids in sand under different conditions, this variation being sufficient to make a difference of 30% in the amount of cement used. Table I shows variation in voids due to difference in moisture alone. The figures in this table are for sand in a loose condition and the differences would be still greater if the dry sand had been shaken and tamped. It is evident that the method of voids is valueless unless the sand is in the same state of compactness when mixed in concrete as it is when the void test is made. Yet, so far as the writer is aware, no one has ever attempted to standardize the method in order that this fundamental condition may be complied with. Doubtless such standardization could be made with sufficient accuracy to meet the requirements of practical work, and would be made were it not for the fact that a more direct and satisfactory method exists for obtaining the same result. A direct test which reproduces actual conditions is always preferable to an indirect test based on assumptions of doubtful correctness. The result desired in proportioning concrete is a mixture of maximum density, and the most direct means to this end consists of density tests. These may be made with concrete or the coarse aggregate may be omitted and the mortar alone proportioned for maximum density. In the latter case the voids in the coarse aggregate must be determined and the concrete so proportioned that the mortar will fill the voids in the gravel or the stone. This method is more justifiable than the method of determining the voids in both fine and coarse aggregate because the per cent of voids in coarse aggregate is less variable than in sand, and also because an error in determining them has less effect on the quantity of cement used. But as a factor of safety the amount of mortar should exceed the voids in the gravel or stone by about 10%.

Method of Proportioning Mortar for Maximum Density.—To proportion a mortar for maximum density proceed as follows: Make a mortar of the cement and sand to be used, proportioning the materials by weight. Tamp this into a graduated glass cylinder and weigh. From the known proportions of the mixture compute the weights of cement and of sand which are now in the graduated cylinder. After the mixture has settled to its final volume compute the per cent of the total volume which is solid material, by using the specific gravity of the cement and of the sand to compute their absolute volume from their weights. The specific gravity of cement may be assumed as 3.1 and that of siliceous sand as 2.65. The per cent of solidity of the mortar thus computed is called its density. Mixtures of different proportions should be tried and the one of greatest density used. From 5% to 10% additional cement should be used in practice as a factor of safety against field conditions.

TESTING COARSE AGGREGATES AND CONCRETE

It is very important to recognize the fact that at the present time field and laboratory conditions are vastly different, so that beyond a limited extent refinements in laboratory practice are wholly unjustified if results of a practical nature are desired. It is only in the interests of theoretical research that the investigator is justified in carrying his methods to extremes of accuracy. One notable difference between field and laboratory is that in the field it is impossible to prevent considerable variation in graded aggregates. Coarse aggregate especially, even though well graded in the beginning, will suffer so much separation of fine from coarse material during handling as often to be unrecognizable when it arrives at the mixer. And such variations in materials are not the only differences between field and laboratory tests. The measurement of aggregates in the field is very crudely made at present. Not only is the actual measurement merely approximate, but no allowance is made for the fact that sand measured in a dry condition contains from 10% to 25% more solid material than when measured moist. This inaccuracy could be remedied by weighing aggregates instead of measuring them by volume, but the

TABLE I.

PHYSICAL CHARACTERISTICS OF CONCRETE AGGREGATES.
(FOR AGGREGATES IN LOOSE CONDITION.)

	VOIDS (Aggregate containing natural moisture.)	VOIDS (Aggregate dry.)	WEIGHT (Lbs. per cu. ft. Aggregate containing natural moisture.)	WEIGHT (Lbs. per cu. ft. Aggregate dry.)	Per cent moisture in moist Aggregate.	Specific gravity of stone.
Average of four good, concrete sands	53%	43%	82	95	5%	2.65
Long Island washed gravel graded ⅜-in. to 1¾-in.	....	36%	..	106	....	2.65
Commercial ¾-in. limestone	....	44%	..	97	....	2.80
Commercial 1½-in. limestone	....	46%	..	95	....	2.80
Trap rock, graded ⅜-in. to 1¾-in.	....	44%	..	103	....	2.95

cost of doing so prevents the method from being put into practice. It is possible, however, that it may sometimes be required for important work at least.

Plasticity should be secured by Thorough Mixing, not by Excess Water.—Variations in field concrete due to difference in consistency are very marked, especially at the age of 28 das., specimens made from plastic concrete averaging much higher in strength than those mixed very wet, owing to the settling of coarse aggregate to the bottom of wet mixes. The time of mixing also has an important relation to the strength, although it has never received the amount of attention which it deserves. It should be self-evident that continued mixing reduces the air voids and so increases the strength. Concrete which is made plastic and mixed until it flows easily is incomparably superior to the "drowned" product so commonly seen on construction work. In any case it is highly desirable to avoid a consistency so wet that the coarse aggregate sinks to the bottom.

Having these several causes for variation in strength of field concrete in mind, the N. Y. subway laboratory endeavors to avoid laying itself open to criticism on the grounds of inconsistent refinements in methods of testing, and this attitude would be fully justified even if concrete were a perfectly uniform product and if its testing could be reduced to an exact science. For even were these conditions complied with, the results of tests would still vary with the size and shape of test specimens, which scarcely ever exactly duplicate the actual structure to be built. The writer feels that he is justified in emphasizing these remarks because at the present time methods of testing and concrete aggregates are beginning to be standardized and it is highly desirable that the standards adopted should be as simple as is consistent with the accuracy which it is possible to obtain.

METHOD OF CURING SPECIMENS

The method of curing concrete has considerable effect on its strength and for this reason test specimens should be stored as nearly as possible under the same conditions as concrete in actual structures. It is customary to store specimens in moist sand, but this is sometimes impossible and is always inconvenient when their number is large. At this laboratory they are stored in a damp basement and are sprinkled daily, but are not covered with sand. Specimens made on the work in winter must be carefully protected from freezing, as they will freeze much more easily than mass concrete. A specimen that is thoroughly frozen before it has set and later is stored in a warm place will show barely ⅓ of its normal strength at 28 das. The rate of speed at which concrete is crushed in the testing machine is another factor that affects the compressive strength and one which calls for standardization by the technical societies in the same manner as is at present specified for testing steel. Until some other standard is adopted the same speed should be used as is used for crushing 2-in. cubes, that is, a speed such that the specimen will be broken in between 1 min. or 2 min. It is important that the pressure should be distributed evenly over the ends of specimens and that no lateral stresses should be developed therein. These requirements are well satisfied by cushioning the ends against "compo" board (a pressed board made from strips of wood between layers of heavy paper, used for sheathing, etc.) This material will yield to small projections without spreading laterally or splitting the head of the specimen.

The most interesting tests thus far made in this laboratory are some comparative tests showing the difference in strength between concrete cast in test-specimen molds and the same concrete when taken out of the actual structure after hardening. The results of these tests were published in *Engineering News,* Feb. 18, 1914. Since the concrete used in them was placed through a chute, the results are valuable in showing that this method of placing can be made satisfactory. Success in using it depends upon employing small batches and on keeping the end of the chute near the working surface, so that the coarse aggregate, the impetus of which causes it to separate from the mortar, will fall on the same spot as the latter.

TESTING CEMENT

In addition to routine tests the laboratory is called upon to make such special investigations and reports as the work may demand. While routine tests of cement are made in another laboratory located at Allentown, Pa., it occasionally happens that this laboratory is called upon to investigate cement which acts in an unusual manner in the field. It is found that different cements, all of which pass standard specifications, will not all act the same under field conditions. Some will set more slowly than others in cold weather, and some will set quickly in hot weather when mixed under field conditions. In such cases quick investigations and tests are made by the laboratory, which reassures the field engineers as to the soundness of the cement and reports on the causes of the peculiarities noticed. Special attention is given to the color of cement to be used in concrete that will remain exposed to view.

WATERPROOFING METHODS

Waterproofing the new subways is a difficult and expensive undertaking. The concrete itself is made as nearly impermeable as possible and where additional protection is needed brick and mastic, or pitch and burlap are used. No integral waterproofing compounds are mixed with concrete. Such compounds, even if effective for the purpose for which they are intended, do not prevent leakage through the cracks that are inevitable in a continuous structure like a subway which passes through all kinds of material and over all kinds of foundations. Several integral waterproofing compounds have been tested, but always with negative results, the directions for use accompanying them specifying such rich proportions that the resultant mixture is impermeable whether the compound is added to it or not. Specimens for test are made in the shape of disks and are subjected to a head of 115′ of water (50 lbs. per sq. in.) for 7 hrs. Only leakage through the specimen is measured, although under different conditions it would sometimes be desirable to measure absorption also.

FIELD METHOD OF TESTING

It may be well to call attention to the value of field tests of concrete and to a method of making them which requires neither laboratory nor testing machine. The results are valuable to the engineer, not only as information for his own use, but also as definite evidence against contractors who refuse to acknowledge the errors of their ways, and in a similar way they are valuable to the contractor when the engineer is inclined to require unnecessary refinements. Such tests are easily made by casting the concrete in beams and loading the latter with bags of cement, the weight of each bag being assumed at 94 lbs. The bags should not be piled directly on the beam, on account of the uncertainty of such loading, but should be laid on a platform supported on the beam by blocks at the ⅓ points. When the load is thus arranged the bending moment is ⅘ of the bending moment for the same load uniformly distributed. As a basis of comparison with the specimens made from day to day several beams should be cast and tested from concrete carefully proportioned, of plastic consistency and mixed for a full minute after all the ingredients are in the mixer.

Material Cost of Concrete Slabs

The cost of material for a concrete slab may easily be obtained graphically by the use of a chart similar to the illustration. This chart which has been figured for a 4-inch slab, was prepared by A. P. Hoover, Engr., with John W. Ferguson Co.[1]

It is evident that the cost of any other thickness of slab would bear to the cost found in this diagram, the same ratio as the slab thicknesses. Thus, a 6-in. slab would cost 50 percent more than the 4-in. slab. The method of using this chart is very simple, as it involves merely the tracing of parallel lines from the price of one material to that of another.

Example—Suppose we assume that the cost of stone is $1.80 per cu. yd.; sand, $1.00 per cu. yd., and cement $1.45 per bbl. The cost of one square foot of 4-in. slab mixed 1:2½:5 would then be found as follows. (See heavy line in the chart.) Follow the line representing $1.80 for stone to the right until it meets the cost line of sand, representing $1.00. From this point, proceed vertically until the cost of cement in the required mixture is met. At the intersection, proceed again, horizontally, to the right, and it is found that the cost is 5 cents. Note that the chart provides for three common proportions 1:2:4, 1:2½:5, and 1:3:6.

This form of diagram recently saved much time in preliminary calculation. It should prove of interest to engineers and contractors generally, as graphical methods, well conceived, and intelligently applied, form the same sort of help to the engineer as does the slide rule.

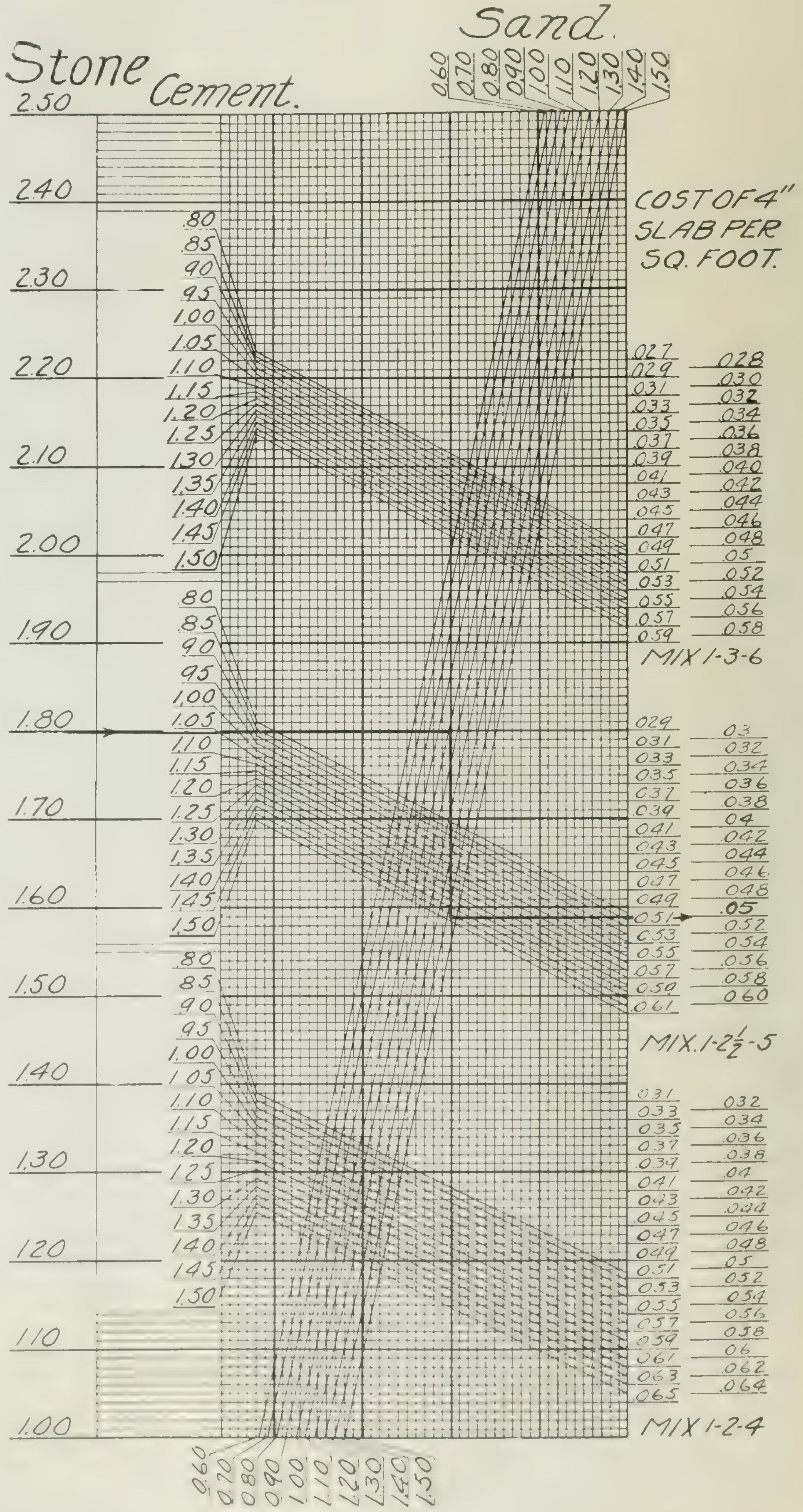

Chart for Determining Material Cost of Concrete Slabs

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[1] Contrs., Paterson, N. J.

Tests to Determine Temperature Effects on Strength of Briquettes

Because most of its construction work is in the northern section of the U. S. and in Canada, and each year it has carried on the work through the winter months, the Aberthaw Construction Co., Boston, engaged Herbert L. Sherman to make briquette tests to determine the action of normal and low temperatures on the strength of briquettes. The series of tests was set up to parallel as closely as possible the conditions existing on building construction carried on in winter weather.

It was desired to learn what heating was necessary to make concrete sufficiently strong so that forms might be drawn, and to find out how strong concrete was under different treatments. It was particularly desirable to learn whether or not concrete, which had been heated for several days and then allowed to cool to the temperature of the winter air, increased in strength, and if so, how fast and how much. This reproduces the common practice of heating a concrete building for some days, and then leaving it unheated. If the tests indicated that concrete does not increase in strength after the heat is removed, or if it increases only very gradually, then there would be little reason for leaving the forms in place beyond the period of heating. If the concrete does not increase in strength after five days' heating, then the strength of the concrete would be that of six-day-old heated concrete, even if the forms are left in place during cold weather for 3 wks. or 4 wks. Leaving the forms in place would mean a waste of money, if conditions are entirely safe at the end of 6 das.

No claim is made that this series of tests is complete, or that it proves anything definitely. It simply shows the strength of this particular set of briquettes, made in the way described.

It is to be noted that the interior of a mass of concrete is protected by the exterior, and that the effect of cold upon a small briquette is more sudden and more thorough than it would be on a large mass of concrete. It must be recognized that concrete throws off heat in setting, and that this setting helps force the set of the concrete. It is desirable to study the matter further with full-sized sections of concrete. It is probably fair to reason that a full-sized section of concrete is less seriously affected than the small briquette.

It is to be remembered that, in heating a concrete structure, the ceiling and the upper sections of the columns are kept very much hotter than the lower sections of the columns, particularly the lower part of the wall columns. And it is very common to design the wall columns with reference to architectural treatment, very often making them much larger than would be necessary to carry their loads. This feature has probably saved many failures.

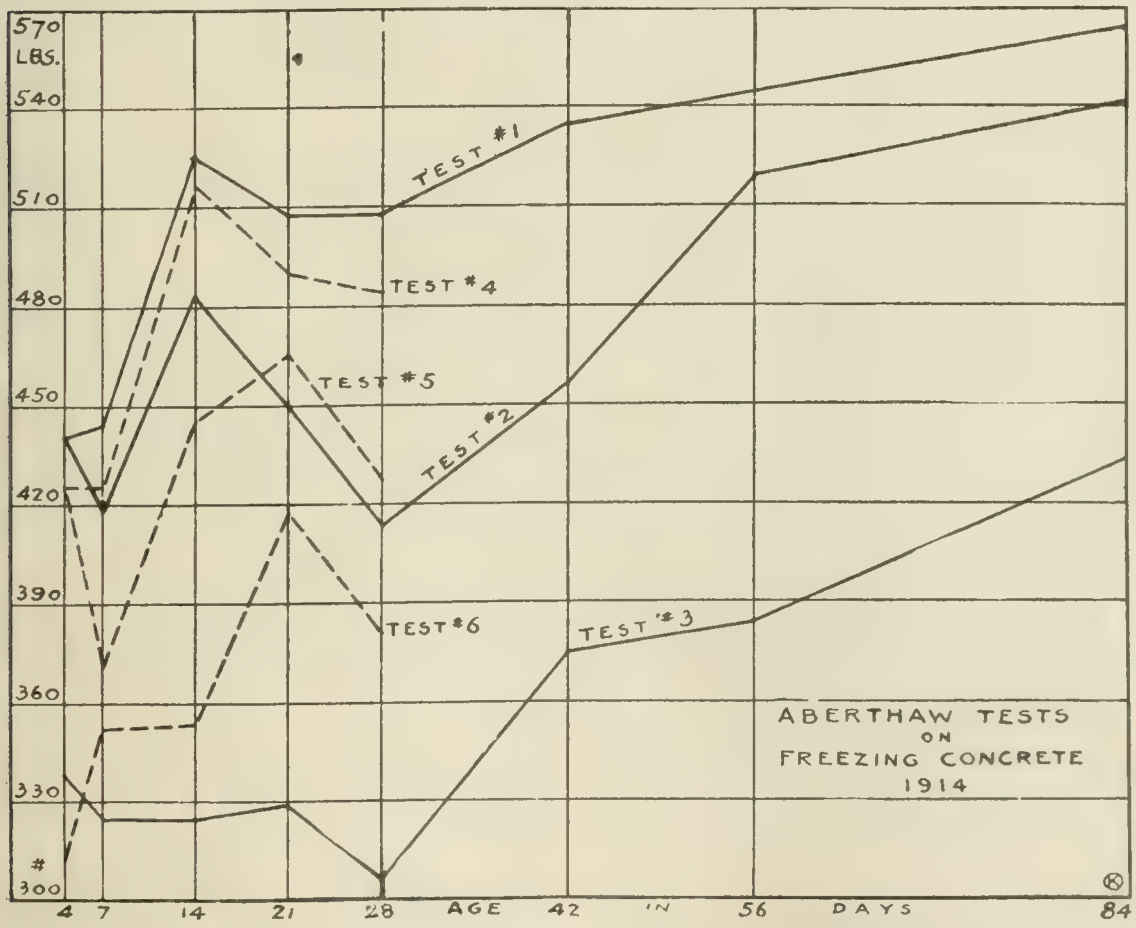
In all the tests, there was used a mixture of several brands of Lehigh Valley cement, and standard Ottawa sand. All briquettes were mixed at the same time by the same man, in a room at approximately 72° F. All briquettes, which were held at between 40° F. and 70° F., were kept moist. Briquettes were treated in a standard machine. Frozen briquettes were allowed to thaw out before testing.

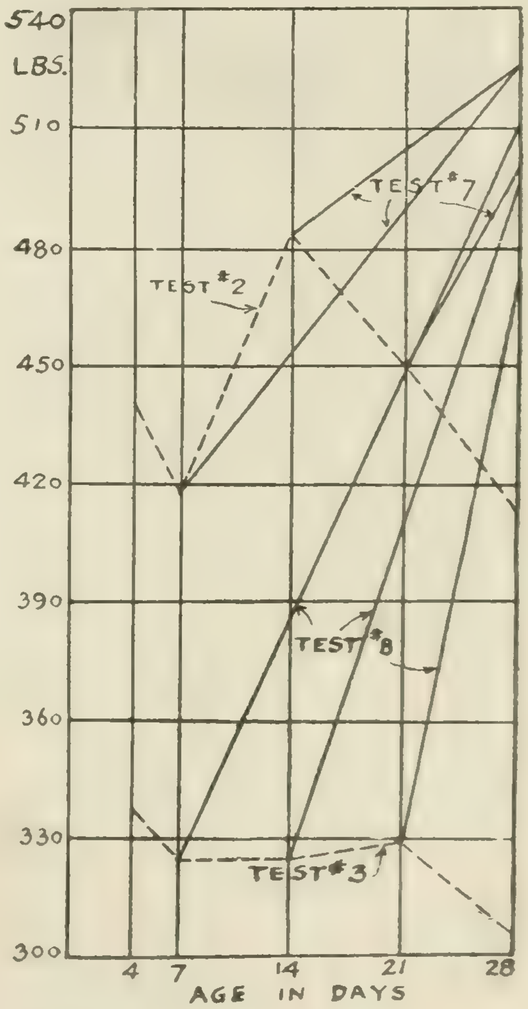
The results of these tests are plotted graphically in the accompanying illustration.

Test No. 1.—For purposes of comparison, these briquettes were made of 1 part cement and 2 parts sand, gauged with water. Materials were approximately 72° F. when mixed, and briquettes after molding were kept at a nearly constant temperature of 72° F. The table shows the result of these tests.

Time	Lbs.	Lbs.	Lbs.		Lbs.
4 das.	...450	422	452	Average	441
7 das.	...463	436	435	Average	445
14 das.	...504	536	532	Average	524
21 das.	...506	494	522	Average	507
28 das.	...502	496	522	Average	507
42 das.	...532	515	557	Average	535
56 das.	......	...	...		...
84 das.	...564	587	542	Average	564

Test No. 2.—Mortar and materials mixed the same and under the same conditions as for No. 1. Briquettes were kept at 72° F. for 4





Results of the Briquette Freezing Tests Made by the Aberthaw Construction Co., Boston das., then placed in cold storage at an even temperature of 29° F. until the time of breaking.

Time	Lbs.	Lbs.	Lbs.		Lbs.
4 das. ...	450	422	452	Average	441
7 das. ...	404	425	427	Average	419
14 das. ...	467	492	492	Average	484
21 das. ...	437	450	464	Average	450
28 das. ...	436	412	394	Average	414
42 das. ...	430	473	465	Average	456
56 das. ...	501	522	533	Average	519
84 das. ...	543	541	538	Average	541

Test No. 3.—Mortar and materials mixed the same and under the same conditions as for No. 1. Briquettes were molded at 72° F., kept at 40° F. for 4 das., then placed in cold storage at a temperature of 14° F. up to the time of breaking.

Time	Lbs.	Lbs.	Lbs.		Lbs.
4 das. ...	328	333	354	Average	338
7 das. ...	305	336	334	Average	325
14 das. ...	315	326	335	Average	325
21 das. ...	304	335	348	Average	329
28 das. ...	304	315	298	Average	306
42 das. ...	378	362	385	Average	375
56 das. ...	367	382	407	Average	385
84 das. ...	463	410	426	Average	433

Tests Nos. 4, 5 and 6 exactly parallel in their order tests Nos. 1, 2 and 3, except that 5% salt solution was used in the mortar, instead of clear water.

Test No. 4.—Same as No. 1, except 5% salt solution used. Specimens were held at 72° F.

Time	Lbs.	Lbs.	Lbs.		Lbs.
4 das. ...	425	433	417	Average	425
7 das. ...	412	425	436	Average	425
14 das. ...	506	518	523	Average	516
21 das. ...	506	472	493	Average	490
28 das. ...	496	493	462	Average	484

Test No. 5.—Same as No. 2, except 5¾ salt solution used. Briquettes molded and held at 72° F. for 4 das., then placed in cold storage at a temperature of 29° F. until breaking.

Time	Lbs.	Lbs.	Lbs.		Lbs.
4 das. ...	425	433	417	Average	425
7 das. ...	386	367	360	Average	371
14 das. ...	458	442	437	Average	446
21 das. ...	456	486	455	Average	466
28 das. ...	442	415	424	Average	427

Test No. 6.—Same as No. 3, except 5% salt solution used. Briquettes were molded at 72° F., kept at 40° F. for 4 das., then placed in cold storage at 14° F. up to the time of breaking.

Time	Lbs.	Lbs.	Lbs.		Lbs.
4 das. ...	325	304	811	Average	813
7 das. ...	360	356	844	Average	853
14 das. ...	346	355	864	Average	855
21 das. ...	412	414	426	Average	417
28 das. ...	374	394	875	Average	881

Test No. 7.—Nine briquettes were made the same as for No. 2, except that three of these were removed from the 29° F. temperature at the age of 7 das., three at the age of 14 das. and three at the age of 21 das. All briquettes removed were kept at 72° F. until they reached the age of 28 das., when they were all broken at the same time.

Time	Lbs.	Lbs.	Lbs.		Lbs.
7–28 das.	527	515	534	Average	525
14–28 das.	516	522	538	Average	525
21–28 das.	512	483	504	Average	500

Test No. 8.—Nine briquettes were made under the same conditions as in Test No. 3, except that three of these were removed from the 14° F. temperature at the age of 7 das., three at the age of 14 das., and three at the age of 21 das. These were all held at 72° F. after removal, and were all broken at 28 das.

Time	Lbs.	Lbs.	Lbs.		Lbs.
7–28 das.	494	512	524	Average	510
14–28 das.	505	486	495	Average	495
21–28 das.	452	474	483	Average	470

For convenient comparison, the table gives the average strengths of each of the eight tests, placed side by side.

	No. 1 Lbs.	No. 2 Lbs.	No. 3 Lbs.	No. 4 Lbs.	No. 5 Lbs.	No. 6 Lbs.	No. 7 Lbs.	No. 8 Lbs.
4 das.	441	441	338	425	425	313	...	...
7 das.	445	419	325	425	371	353	...	...
14 das.	524	484	325	516	446	355	...	...
21 das.	507	450	329	490	466	417	...	...
28 das.	507	414	306	484	427	381	...	...
42 das.	535	456	375	...	...	...	...	...
56 das.	...	519	385	...	...	...	...	...
84 das.	564	541	433	...	...	...	...	...
7—28 das.	...	...	...	...	...	...	525	510
14—28 das.	...	...	...	...	...	...	525	495
21—28 das.	...	...	...	...	...	...	500	470

From tests Nos. 4, 5 and 6 it was hoped to find whether or not the presence of salt was any aid to the hardening of concrete at temperatures below the freezing point. From tests Nos. 7 and 8 it was hoped to find whether or not concrete which was first subejcted for a limited period to warm weather, then frozen, then thawed out and kept warm, would recover promptly and become as hard as concrete in summer conditions.

Concrete Foundations for Farm Engines[1]

To obtain the highest efficiency an engine should have a heavy and firm foundation. This will not only reduce wear and tear incident to excessive vibration, but will result in prolonged and better service.

After the exact location of the center line of the foundation has been carefully established, a pit 2′ to 4′ deep should be excavated, the length and width being the exact size of the footing. Deposit the mushy wet concrete to the depth determined on the plan. In order thoroughly to key the engine foundation to the footing, embed 3-in. or 4-in. stones in the portion of the footing under the engine so that they will protrude from the footing.

A box form 8″ larger in length and in width than the engine base should be carefully set over the footing. The inside of the forms should be thoroughly oiled to prevent the concrete from adhering to them. It is essential that the anchor bolts for the engine be carefully spaced and so placed as to take care of any small variations in position. Use a template for this purpose, and supply for each bolt greased gas-pipes of twice the diameter of the bolts, the pipes to be removed before the engine is set. The purpose of the pipes is to provide for such slight adjustment of bolts as may be required. The anchor bolts should be embedded in the concrete at least 18″, and supplied with cast-iron washers at the lower ends.

After the template has been accurately set over the forms and the bolts so arranged that the tops are at proper elevation, the concrete is carefully deposited and spaded in the forms. Turn the gas-pipes from time to time, thus preventing them from sticking to the concrete. The concrete along the forms should be carefully spaded to prevent the formation of air-bubbles or pockets.

Damp burlap should be placed over the form after the concrete is placed. This will insure normal setting of the material. After 24 hrs. remove the form. The engine may be set and the bolts adjusted after 48 hrs. Before the engine is set remove the gas-pipes referred to above, and when the engine is finally placed, fill the space around the bolts with 1:1 mortar.

Do not use the engine until the base is at least 2 wks. old. If necessary to have an exhaust or drain pipe, this may be installed in the form before the concrete is deposited.

The monthly *Record* of the Assn. of Am. Portland Cement Mfrs. says, under the title, "Novel Methods of Timing Mixture:

> An inexpensive and novel method of timing the mix is being used on the concrete paving being placed by the U. S. Steel Co. at Ojibway, Ont. A minute-glass mounted on a pivot placed in a cigar-box has been placed on the mixer in a position convenient to the operator. When the hopper is raised, the operator reverses the sand-glass by swinging it on the pivot, and when the upper part of the glass is empty, the batch is ready to dump. As a one-min. sand-glass could not be secured for this purpose, the end of a three-min. sand-glass was filled and the sand for a two-min. period was removed. The apparatus is quite simple and will insure a definite time of mixing instead of the usual guess methods employed.
>
> It should be noted that the time of mixing should be governed by the particular mixer used.[1]

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[1] From material supplied by the Assn. of Am. Portland Cement Mfrs.

[1] See CONCRETE, Oct., 1914, p. 162

Information and Consultation: The How-to-Do-It Department □ □ □

This magazine is for service. Let it serve you, and you help it to serve. You want special information. Ask us. We know the men who know.

Boiler Capacity for Steam Curing

The Question Below is Discussed By:

W. M. Kinney[1]
A. E. Cline[2]
R. F. Havlik[3]

"Knowing the cubic contents of steam curing rooms, how shall I figure the boiler capacity necessary to maintain the proper heat and moisture in the rooms, using steam with only enough pressure to force it into the curing rooms, and to have a continuous, warm, foggy atmosphere without the necessity of night firing? This, I believe, is the problem with most concrete products manufacturers. In my case there are three curing rooms, each 18′ long, 8′ wide and 6′ 6″ high."

By Mr. Kinney

In addition to the data given below, it would be necessary to know the type of construction of the curing rooms, their exposure, the distance at which the boiler would be located from them, and the difference in elevation between water level in the boiler and in the pipe line. As to the type of heating system which should be selected, it would be necessary to know the capacity of the products plant, whether steam power is used for manufacturing the products, thus making it possible to use exhaust steam from an engine, or whether steam must be obtained direct from a boiler provided for the purpose. Not having these data, it will be possible to give only general suggestions for the layout of such a plant.

For the proper curing of cement products, it is desirable to maintain a temperature of from 100° to 130° F. in the chamber, and a humidity of 100% as registered by a hygrometer. The recommendations which have, perhaps, received widest recognition and adoption to produce the desired conditions just described above, contemplate admitting steam to the chamber in which the products are to be hardened by means of a perforated pipe, placed perforations down, in a trough or gutter of water. R. G. Rosenbach[4] suggests that the desired conditions be obtained with a heating system by means of which temperature and humidity can be controlled separately. Moisture can best be obtained by heating water in a trough, gutter or reservoir, by passing a steam coil or pipe through it. This eliminates the possibility of dry steam and also conserves the boiler feed. The water in the reservoir can be kept at a constant level by installing a float valve so that as water is evaporated it will be automatically replenished from a prearranged source of supply. It is probably best to have the trough in the center of the floor, running throughout the length of the curing chamber. It can be covered by a slat flooring, made so as to be easily removable. The heating coils may be placed vertically against the walls or horizontally above the floor. The latter scheme would probably give the better distribution of heat. If the plant operates by steam power, it may be found economical to use exhaust steam from the engine. In this case a vacuum system of supply would doubtless be the more economical, both in supplying the curing rooms and in relieving back pressure from the engine. If the plant is a large one but not operated by steam power, it might be more economical to use the vacuum system. If the plant is small, a gravity system would more likely be the better; that is, one in which boiler water level is below the steam pipe line, so that all condensed water in the pipes will drain back into the boiler. With this system the matter of boiler feed would be simple and would require but little attention.

There are several companies that supply this class of equipment. Each of these companies employs expert engineers who are prepared to design a plant either large or small on a basis of economy.[5]

By Mr. Cline

I do not know of any rule by which one can figure the size of boiler required, except the rule of experience. I have had a 10-h. p. upright boiler successfully steam three rooms, each 16′ x 16′ x 7′ high, but we had to keep steam on all night.

A horizontal return flue boiler is far the most economical, as well as efficient, for its large steam chamber means less attention, and steadier heat and moisture.

With a boiler of this type, keeping it fired until 10 o'clock or 11 o'clock at night, then banking the fire, one would probably find the rooms warm and moist in the morning even if not foggy; but unless some steam is kept coming, it does not take long for the room to cool enough to condense the steam.

A 10-h. p. boiler would be ample for such rooms under steady heating, but for non-firing at night I would advise a 20-h. p. horizontal return flue boiler, and then fired until late at night.

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[1] Engr. in charge Information Bureau, Universal Portland Cement Co., Chicago

[2] Winchester, Kans.

[3] Supt. of Construction, Mooseheart, Ill.

[4] Mechanical Engineer for Warren Webster & Co.

[5] Among these companies are: Warren Webster & Co., 1510 Monadnock Block, Chicago; Consolidated Engineering Co., 507 W. Jackson Blvd., Chicago; Illinois Engineering Co., 540 W. Harrison St., Chicago

By Mr. Havlik

We use a 35-h. p. boiler for heating our plant and also for supplying steam to four curing rooms that are approximately 8′ wide, 64″ high on the sides, about 7′ 6″ high in the center and 64′ long. We find that this boiler is ample for the purpose. In the case of this present inquirer, the cubical contents of the curing rooms figure approximately ¼ of our plant, so a 10-h. p. boiler would be large enough if used for curing only.

The Use of Lime Hydrates in Factory-Made Concrete Units

The Question Below is Discussed By:

E. L. Conwell[1]
E. W. Lazell[2]
H. B. H. Hurd[3]

"1. In connection with the use of hydrated lime in the manufacture of concrete stone, how do results obtained differ in the use of a calcium hydrate and a magnesian hydrate? We are thinking of making some use of hydrated lime in our factory, and we should like to know whether or not it is true that magnesian lime sets more slowly than calcium lime. We should also like to know whether or not it is true that some calcium hydrates are scorched or burned in the hydrating process. If this is so, what effect would it have in the use of such material in concrete?

"2. In the use of hydrated lime in concrete stone, we understand that there is a certain efflorescence when the product is green, which passes away in a short time. Is this true?"

By Mr. Conwell

In answering this question, I think it wise to outline certain salient facts in regard to hydrated lime which are not generally appreciated. Hydrated limes are divided according to their chemical composition into two classes, viz., high calcium and magnesian. The high calcium hydrates contain but little magnesia; while the magnesian hydrates contain in the neighborhood of 30% of magnesia, as illustrated by the following analyses:

Class	High Calcium	Mgn's'n
Silica (SiO_2)	.88	2.02
Alumina and Iron Oxide (R_2O_3)	.50	.56
Calcium Oxide (CaO)........	66.20	48.13
Magnesia (MgO)	.74	32.00
Loss on Ignition	30.92	17.02

The difference in the chemical composition of these two varieties of hydrate is plainly reflected in their action during manufacture and to a somewhat lesser degree in their properties when used. Their manufacture is simply slaking by mechanical means and the manufacture of high calcium hydrated lime of good quality is much more difficult than that of magnesian. The reason for this is found in the fact that high calcium lime slakes much more rapidly than magnesian and consequently it is difficult to get the water thoroughly mixed with the lime before the slaking process has begun.

The high calcium lime requires more water and evolves more heat than does the magnesian, owing to its high content of calcium oxide and hence is much more liable to be scorched or burned in the process of hydration. This scorching or burning is due to the heat developed which drives off some of the water required to hydrate the calcium oxide. The result of this scorching or burning is a hydrate which is very defective in plasticity, being granular and sandy in its nature, and one which frequently contains particles of unslaked lime, which have often been found to hydrate after the material has been used in construction work, giving rise to popping, pitting and disintegration generally.

With magnesian hydrates, conditions are somewhat different. The calcium oxide is diluted by the magnesia, hence the slaking or hydration is a slower and cooler preocss and it is comparatively easy to keep enough water in contact with the lime to prevent scorching or burning. Evidences of scorching or burning are very rarely found in magnesian hydrates.

Generally speaking, magnesian hydrates are more plastic and easier working than high calcium hydrates. This is supported by the fact that many thousand tons of magnesian hydrate are annually sold in this country for use in white coat, while the amount of high calcium hydrate sold for this purpose is negligible. For use in cement mortars or concrete, there appears to be little preference, however, between magnesian and high calcium hydrates of good quality. The plasticity of the magnesian hydrate is likely to be somewhat better than that of the high calcium hydrate but in cement mixtures this cannot be detected. It is frequently stated that high calcium lime sets more quickly than magnesian, but when hydrated limes are used in cement mixtures to improve plasticity and density of the resulting concrete, the rapidity of the set of the hydrated lime used is of no importance, as the hardening of the concrete is due entirely to the cement, which is affected either slightly or not at all by the addition of the hydrated lime.

The best test to apply to a hydrated lime, either magnesian or high calcium, to determine its value, is to have a chemist determine whether or not it contains sufficient water to satisfy the calcium oxide present and whether or not it contains coarse particles of unhydrated lime. If hydrated lime contains sufficient water to satisfy the calcium oxide content and is uniformly fine and free from coarse particles, its use is to be advocated, irrespective of whether it is high calcium or magnesian in nature.

Regarding the appearance of efflorescence on concrete products containing hydrated lime, it must be stated that this opens a question about which little is known. Efflorescence appears on concrete, brick work, masonry and other materials at various times and is undoubtedly due to the presence of salts soluble in water which have been brought to the surface by water which has subsequently evaporated, leaving the salts on the surface in the form of fine powder or needles. There are many salts which may cause efflorescence and these salts are found in Portland cement itself, lump lime mortar, hydrated lime mortar, in gypsum or hardwall plasters, in some varieties of building stone, in bricks and in earth. It is, therefore, extremely difficult to state definitely that efflorescence appearing on concrete is due to the cement, the hydrated lime, the sand, the stone or the gauging water. Any of these factors may cause efflorescence.

The writer would not regard the appearance of efflorescence on concrete stone as a very serious matter. In fact if he were a manufacturer of concrete stone, he would prefer to see the efflorescence develop when the stone was green and was still under his control than at a later date, when it had been used in a building and was likely to bring complaint from the owner.

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[2] Edwards & Lazell, Portland, Oregon

[3] Pres., The New England Stone Co., New Haven, Conn.

The best treatment of efflorescence is to permit it to develop fully and after the surface on which it has appeared thoroughly dries, either brush it off with a stiff, dry brush, or wash the surface down with dilute muriatic acid. The brushing treatment has been most satisfactory in the writer's experience, as this completely removes the efflorescence, while washing down with acid partly removes it, but is likely to start another case of efflorescence.

By Mr. Lazell

Exactly similar results can be obtained by the use of either high calcium or dolomite (magnesian) hydrates. The small amount of hydrated lime used will have no appreciable effect upon the setting time of the cement.

It is true that the magnesium limes set somewhat more slowly when used by themselves than the high calcium limes. They, however, develop greater strength after a few months' time. There is little, if any, difference in the strength of cement mortars to which small additions of hydrated lime have been made whether high calcium or dolomite limes are used.

In 1908 the writer presented the results of some tests made on hydrated lime cement mortars to the Am. Soc. for Test. Mat. The hydrate used in all these cases was a dolomite hydrate manufactured in eastern Pa. Good strengths were developed up to the one year's time.

In 1910 the writer again presented the results of both compression and tension tests on various cement mortars to which different additions of hydrated lime and lime paste, made from lump lime, were made. Two conclusions have been drawn from the series of tests.

1. That all lime mortars, whether they contain Portland cement or not, are stronger when prepared from hydrated lime than when prepared from quick lime.
2. That in general mortars made from dolomite lime, whether they contain Portland cement or not, are stronger at the end of one year than those made from high calcium lime.

Referring to the second question as to efflorescence, I would state that my experience has been that the use of the correct amount of hydrated lime does not increase efflorescence.

By Mr. Hurd

Magnesium lime does set more slowly than calcium lime. I do not know that calcium lime is scorched or burned in the hydrated process. It should, however, have no effect in the concrete. In reply to your second question, we have never seen efflorescence appear on any of our products in which hydrated lime has been used, either while green in our factory or after a considerable time in the building.

[*Editor's Note.*—The New England Stone Co. uses from 15% to 20% of hydrated lime by weight of cement in making a high grade of concrete trim stone and ornamental work.]

Effect of Lightning on Concrete Structures

The question below is discussed by:

William M. Kinney[1]
R. A. Steen[2]
H. T. Genung[3]

"What data have you on the effect of lightning on concrete stacks and other tall structures? Will the reinforcing act as a lightning conductor?"

By Mr. Kinney

Where lightning has struck concrete chimneys the effect has usually been confined to the knocking off of a small section of concrete at the top of the chimney, the lightning apparently at once reaching the reinforcing steel which forms a suitable conductor for it to the ground.

One or two cases have come to our notice in which concrete silos have been struck by lightning, but no serious damge has been done, the effect being similar to that observed in the cases reported to us by the chimney construction companies. One suggestion has been made—that several of the vertical reinforcing rods in the chimney be extended above the top of the chimney a short distance to act as lightning conductors, but as a rule reliance is placed on the reinforcing embedded in the concrete to carry the lightning safely to the ground.

It seems to be the custom of concrete chimney construction companies not to place lightning rods on the chimneys unless the owner expresses a wish for this additional protection.

By Mr. Steen

We have had a number of concrete chimneys struck by lightning without any serious effect in any case; the usual result has been to knock a piece of concrete out of the head until the current came in contact with the reinforcing steel and apparently carried off without any damage to the chimney. We believe that in one instance the current was carried down in some manner and went out at the breeching connection, doing some damage, but we never had any accurate details about this matter. There was no damage done to the chimney.

One of the largest chimneys we ever constructed, 350′ high, was struck by lightning and we have a piece of the concrete which was knocked out the top, but no damage was done to the stack, requiring any repairs.

No one can tell what lightning will do, as it acts differently in almost every case, but the above has been our experience. As compared with brick chimneys, we do not think there is much occasion for putting lightning rods on concrete chimney, as the damage done would not seem to be great, while in the case of a brick chimney, lightning will usually knock it down or ruin the whole structure.

By Mr. Genung

The following letter, which we recently received, describes the effect of lightning on a concrete silo:

Our silo was struck by lightning. The current seemed to follow the wire reinforcing around the silo and chipped out a few small pieces, in all amounting possibly to 1 cu. ft. or 2 cu. ft. None of the chips was deeper than 3″. Our silo is a 6-in. wall at the bottom and 4-in. at the top. It is 36′ 2″ inside diam. and 54′ high.

Most articles on insomnia tell you how to avoid it, or how to cure it. Sleep is a desirable—a very necessary habit. Lack of sleep for a long time will kill a man—really dead. But too much sleep will kill a man too—not kill his body, but ruin his mind, master his ambition, get a hammer-lock on his progress. Not too much real sleep in the actual sense of the term, but too much believing one is awake and active and not being really awake and actively interested in the possibilities which lie in everything, and everywhere.—*Atlas Almanac.*

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[1] Engr., Universal Portland Cement Co., Chicago

[2] Pres., Weber Chimney Co., Chicago

[3] Sec. and treas., Polk-Genung-Polk Co., Ft. Branch, Ind.

Correspondence: A Department in Which the *Reader* Becomes the *Writer*

This is your department. It is informal. Use it. This is the place for letters which have either inspiration or information for the "other fellow." It is well to remember that you are usually in his position. If you are to get the good out of these columns, why not help to make them good? Write about your work. Help the Other "other fellow."

Prevention of Dusting of Concrete Floors

A Letter From J. P. H. Perry[1]

Practically all untreated floors will air slack if not used. This air slack occurs in the top film of cement brought to the surface by the steel troweling. To get away from this we have recently been grinding our floors with a terrazzo polishing machine.

Regarding the treatment of floors, to prevent dusting, we have had some experience with the various iron dust or iron filing preparations. We find that these have considerable merit if properly applied at the time of placing the granolithic finish.

We have also used some of the chemical floor hardeners. These appear to increase the wearing value of the floor, though it is doubtful that they eliminate dusting under hard wear.

Of surface treating preparations of another character the best that we have ever seen is Valsement,[2] a really remarkable waterproof and stainproof preparation which is suitable for light wear and is ideal for all loft, office buildings, hotels, etc.

We have looked with some favor on the Waxement[3] process, which consists in heating floors and impregnating special wax compounds. This process apparently does away with all dusting under the most severe wear. It makes the floor easier for employees to stand upon for the reason that it gives a certain resilience to the floor. It probably also has some value in waterproofing a floor.

There seems to be no doubt that concrete floors to give satisfaction must be treated in some one of these five ways, the particular process used should be selected only after study of the case in hand. For light wear a surface treatment such as Valsement is usually satisfactory; for severe wear either an iron filing preparation or wax impregnation is to be desired.

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[1] Turner Construction Co., N. Y. C.

[2] Valentine & Co., N. Y. C.

[3] Waxement Co., N. Y. C.

Hydrated Lime in Spouted Concrete

A Letter From G. J. Griesenauer[1]

In your editorial on p. 91 of the Sept., 1915, issue, "The Chute and Tower," you say: "The only objection to its use (the chute and tower) is the tendency, in order to secure an easy flow, to use too much water, causing a dangerous separation of the concrete. This is a very real danger against which one must always be on guard. The *flow of concrete* depends not only on its fluidity secured by excess water, but also upon its plasticity, which is an entirely different property."

The last paragraph of this editorial says that a small amount of hydrated lime in the mix aids greatly *in securing the easy flow* required and is a valuable ally in obtaining dense and waterproof concrete.

Note that in referring to hydrated lime you do not say that it also is a safeguard against separation and settlement of the aggregate in concrete liquid enough for spouting. I am under the impression that hydrated lime is a most valuable addition to semi-liquid concrete on account of this fact alone.

I have underlined *"the flow of concrete"* and *"securing the easy flow"* to emphasize the desirable condition the hydrated lime imparts to the plastic concrete.

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[2] Cement Tester, C. M. & St. P. Ry., Chicago

Organizations

American Concrete Institute, Charles L. Fish, Secretary, Harrison Building, Philadelphia, Pa.

American Concrete Pipe Association, Secretary, E. S. Hanson, 538 S. Clark St., Chicago.

American Highway Association, I. S. Pennybacker, Jr., Executive Secretary; Colorado Bldg., Washington, D. C.

American Road Builders' Association, Secretary, E. L. Powers, 150 Nassau St., N. Y. C.

Association of American Portland Cement Manufacturers, Percy H. Wilson, Secretary, Bellevue Court Building, Philadelphia, Pa.

Cement Products Exhibition Co., 208 S. LaSalle St., Chicago, Ill.; Robt. F. Hall, Secy., Chicago Cement Show, Coliseum and First Infantry Armory, Feb. 12-19, 1916.

Mid West Cement Users' Association, Secy.-Treas., Frank Whipperman, Omaha, Neb. Convention, Omaha, Mar. 1-4, and Mid-West Cement Show, Feb. 29-Mar. 4, 1916.

Second National Conference on Concrete Road Building, J. P. Beck, Sec'y, 208 So. LaSalle St., Chicago. Chicago, Feb. 15-18, 1916.

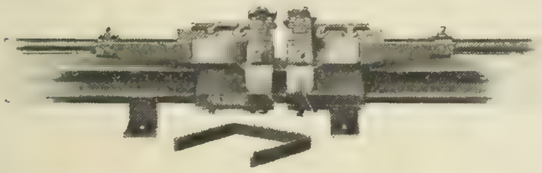
The Hydrated Lime Bureau

It has been found in recent years that the judicious use of a small percentage of hydrated lime performs certain functions necessary to good concrete, such as segregation of the aggregates during placing, reducing shrinkage cracking to a minimum and making the concrete watertight, thereby reducing the expansion and contraction of the concrete, due to the absorption and expulsion of water. The use of from 5% to 15% of hydrated lime, (by weight of the cement ingredient), has been steadily growing in favor with engineers, architects and contractors, due to the past results obtained by the use of this material.

It having been deemed advisable by the Natl. Lime Mfrs. Assn. that a central point be established to reply promptly to inquiries as to the use of hydrated lime, the Hydrated Lime Bureau of the Natl. Lime Mfrs. Assn. was organized and opened to business Jan. 1, 1915, in the Oliver Bldg, Pittsburgh. Through this Bureau many engineers and contractors have learned the real value and advantage of hydrated lime when used in concrete, with the result that they are now specifying this material.

New Equipment, Methods and Materials:
New Tools with Which the Industry Works □ □

This magazine will not publish "reading notices," so-called, for the benefit of advertisers. These pages are edited for the Reader, as are all other pages in "Concrete." Manufacturers are constantly producing new and better methods and developing old methods, materials and machines. The progress of the concrete field is measured by the development of its tools. All developments along these lines are of real interest and importance to men who want to improve the quality of their work, decrease its cost, increase its quantity. This department is for just that kind of Editorial material. We, therefore, welcome detailed announcements which will be of practical value to Readers. Under no circumstances will this magazine publish any announcement simply because an advertiser asks it, nor refuse publication because a non-advertiser asks it. Material must carry information of real consequence to the reader. All material will be edited on that basis regardless of the source from which it comes.—THE EDITORS.



WALLACE DOUBLE LEVER BAR BENDER

A Double Lever Bar Bender

This new machine known as the Wallace No. 1 Double Lever Bar Bender[1] produces means for making right- and left-hand bends with great speed and accuracy.

The two heads are mounted on an angle iron base designed to be bolted to a bench. Set screws are provided to prevent slippage of the stock. Round bars up to 5/8" and squares to 1/2" can be bent cold. Besides the regular dies for square bending, special dies can be provided to bend any shape likely to be wanted.

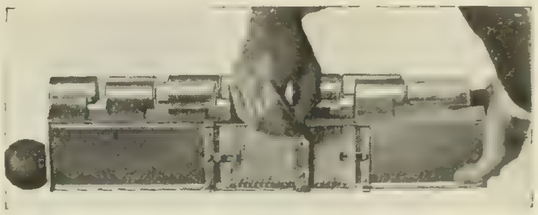
A Rapid Sand Testing Device

A device has recently been perfected and put on the market for determining the grading of sand. This is done by the man on the job, without the necessity of employing highly skilled labor or delicate laboratory apparatus.

In concrete work, it is important that the concrete shall be as nearly like natural stone in texture as possible; and to accomplish this result it is essential first, that the materials shall be free from dirt; and second, that the sand and stone shall be so graded as to size that the finer particles will progressively fill the spaces between the larger particles, so that the larger pieces may not lie like a pile of cannon balls, with very wide spaces between. It has been impossible to obtain this result in the field because of the delicacy of the apparatus required and the care that had to be exercised in using it. To obviate these disadvantages and to enable the sand user to find out just what quality of materials he is paying for and just what sort of concrete he can make with it, the instrument[1] in the accompanying illustration has been developed.

It consists essentially of a small rectangular metal casing, carrying within it a series of graded screens of accurately known mesh or opening and the container is of such strength that these screens will not be damaged by ordinary rough usage. In operating the apparatus the small metal measure full of sand from the pile, barge or bank is put into the casing through a hole in one end. Water is then poured into the casing, the open end plugged and the instrument slowly agitated, causing the water to carry the sand up on the sloping screens in much the same way as waves on a sloping beach carry sand particles with them.

This secures the coarse grading of the materials. The finer grading is secured by holding the instrument in a slightly slanting position and pulsing the rubber bulb five or ten times. This results in a surge and resurge of the water in the casing, lifting the materials from the screens and drawing even the finest gradings through. The instrument is then turned over, when the graded materials run into the metal passageways provided for them. These passageways communicate with glass vials which lie parallel with the long axis of the instrument, so that after the materials are in the passageways, by turning the instrument into a vertical position the various grades of fineness of any sample of sand will appear directly in the vials.



SAND TESTING DEVICE

It is necessary after doing this to obtain a permanent record of the result, on a prepared record sheet and a sliding plate, which is virtually a mechanical adding machine. What the operator does after separating the materials in the manner before described, is to place the sliding index successively at the top of the sand in each vial, sliding the platen along and drawing pencil lines along the edge of the index cards and record sheets. Records may be made in duplicate or triplicate as desired.

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[1] Wallace Supplies Mfg. Co., Chicago

[1] Concrete Appliances Co., Inc., N. Y. C.

The entire operation of grading sand and making a record of its composition takes only about 2 min. with an ordinary operative, as against 2 hrs. or 3 hrs. of highly skilled laboratory procedure by former methods. With this little instrument the dealer and shipper of sand can determine the quality and uniformity of his product; the engineer and the architect can, with its use, pass on the quality of sand offered for use on work and keep accurate check on the material as supplied. The contractor can always tell whether or not he is getting as good sand in every load as he originally bought. The manufacturer of concrete products can insure the uniformity of the goods he makes.

Concrete Pallets for Making Silo Staves

The pallet problem for the manufacture of silo staves made to the curve of the silo was solved by the Battle Creek Silo Co.,[1] by the use of concrete. A wooden pallet of the desired curvature is expensive; a metal pallet was not satisfactory. The concrete pallet is made with an outside frame of ½-in. angle iron with a No. 10 wire reinforcing welded in place on the iron frame, using three long wires and 12 short ones. This is done at a machine shop. This frame is filled with a 1:3 mix of concrete carefully troweled to shape. The pallets are painted on the back side. They are ½″ thick, 14″ x 33″, and weigh 28 lbs.

Two Types of Adjustable Inserts

Two new inserts which permit a certain amount of adjustment are now available.[2] Both inserts provide for adjustment by means of a bridging washer placed under the nut. While the bolt and washer are easily placed in position when held at the proper angle with the insert they cannot be displaced by accident. The illustration shows that the device has a liberal longitudinal as well as a slight lateral adjustment.

The Diamond X, Fig. 1, is a skeleton type closed by a spring steel friction cover.

The Diamond N, Fig. 2, is a heavy malleable iron casting to be used where excessive strength is needed.

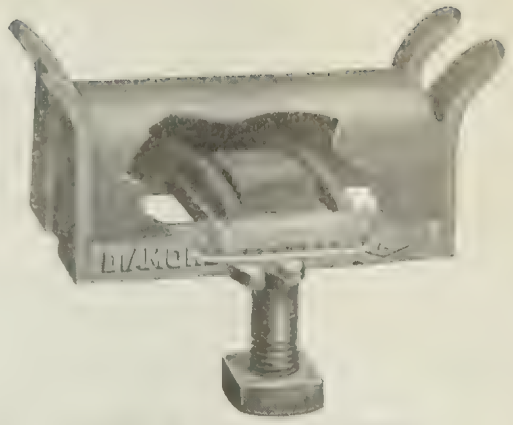


Fig. 1—The Diamond X Insert

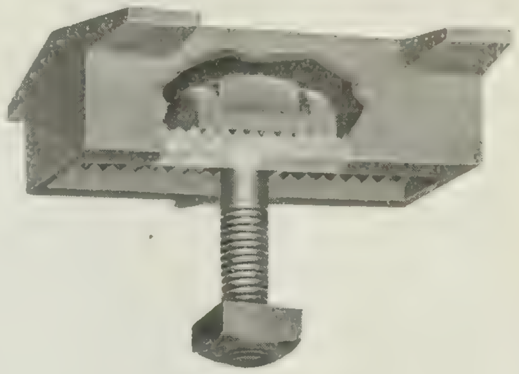
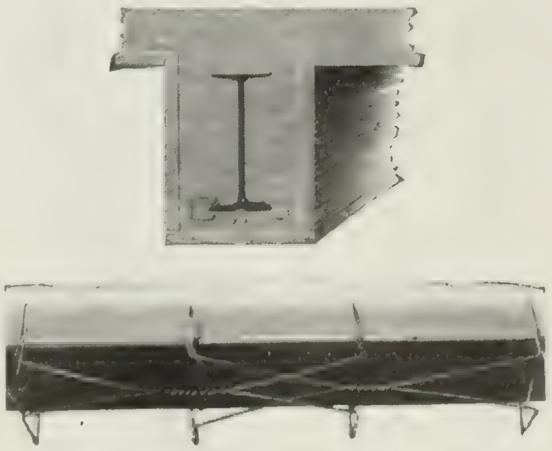


Fig. 2—The Diamond N Insert

Reinforcing Clip for Steel Beam Fireproofing

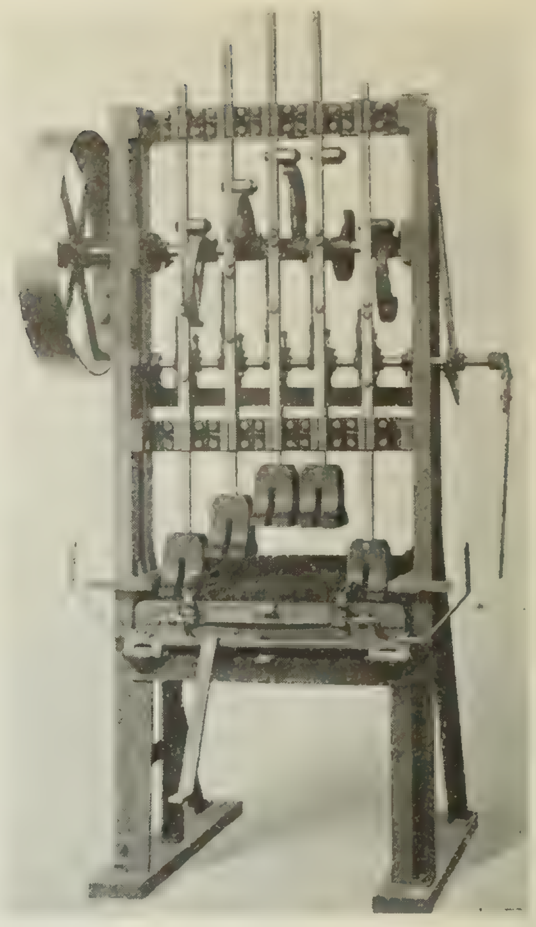
Modern fireproofing methods demand that all steel members shall be covered with a material which will protect them from heat. Concrete has been found the very best possible protection. The weakest point of the concrete protected beam lies in the horizontal plane of the lower flange where deflection of the beam is liable to split the concrete and allow it to spall. An examination of the device illustrated[1] will show that it has been designed so as to provide a direct reinforcement at this critical point. It has also the advantage of being extremely simple and can be applied to the beam without tools and very rapidly.



X-Tension Clip for Fireproofing Steel Beams

Concrete Brick Machine

Here is another brick machine—the Ideal Model F.[2] It makes 10 brick at a time. In the accompanying illustration it is set up under an automatic tamper, operated with 1 h. p. It is intended for use in making either faced or common brick.



New Ideal Brick Machine

Report on National Frostproofing

Some time ago[1] this magazine described, under the name of Frostproofing[2] a powdered material said to prevent concrete from freezing. It is a fine white substance to be combined with the batch in proportions of 2½% to 4% of the weight of the cement used. At that time, tests were being made by disinterested persons to determine the value of the material.

J. R. Worcester & Co.[3] conducted elaborate tests to determine:

(a) Whether or not the mixture of Frostproofing with cement has any deleterious effect.

(b) What, if any, effect the material has on setting properties at low temperature.

Four lines of experiments were undertaken, as follows:

(1) Placing bright steel in water containing Frostproofing and also in pure water, to determine the relative rusting.

(2) Exposing mixtures of different proportions of Frostproofing and water to various low temperatures to determine the effect upon the formation of ice.

(3) Preparing briquettes of mortar composed of cement containing various proportions of Frostproofing and Ottawa sand and exposing them to atmosphere at low temperature to determine the relative effect.

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[1] Battle Creek, Mich.

[2] Diamond Expansion Bolt Co., N. Y. C.

[1] Concrete Steel Co., N. Y. C.

[2] Ideal Concrete Machy. Co., Cincinnati

[1] Mar., 1915, p. 95

[2] G. O. Sanders, Boston

[3] Cons. Engrs., Boston

(4) Preparing 6-in. cubes of concrete with different proportions of Frostproofing and subjecting them to varying degrees of low temperature and then crushing them.

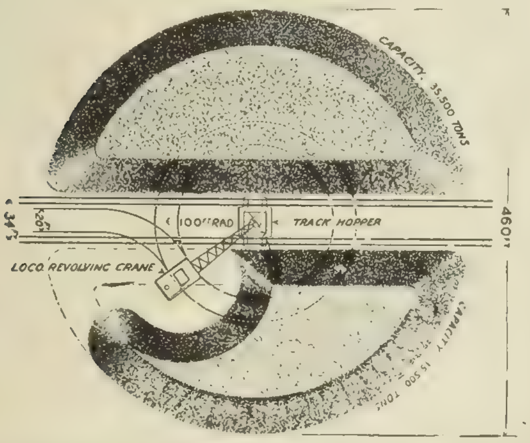
Mr. Worcester's report sets forth in detail the procedure followed and the results obtained, from which the following findings are abstracted:

At the end of a month, steel showed less corrosion in water containing Frostproofing than in clear water. From a series of five tests the conclusion is drawn that about 2% of Frostproofing is sufficient to prevent mortar from freezing under ordinary winter conditions. That the compound has no effect upon the tensile strength of the mortar even when used in amounts as high as 6%. The addition of Frostproofing up to 5% does not lower the compressive strength of concrete. The addition of 2½% is of distinct benefit in hastening the hardening of concrete in cold weather. The addition of 2½% is sufficient to allow hardening at constant temperature as low as 12°, while at a temperature of 2° even 5% did not prevent freezing and suspense of hardening. The following conclusions were given by Mr. Worcester as the result of the work:

(1) The Frostproofing in less than 5% strength does not appear to be harmful to steel or to tensile or compressive strength of mortar or concrete.

(2) Frostproofing appears to be advantageous in preventing freezing and hastening the hardening of concrete under ordinary winter conditions.

(3) It appears that 2½% is as useful as a larger proportion.



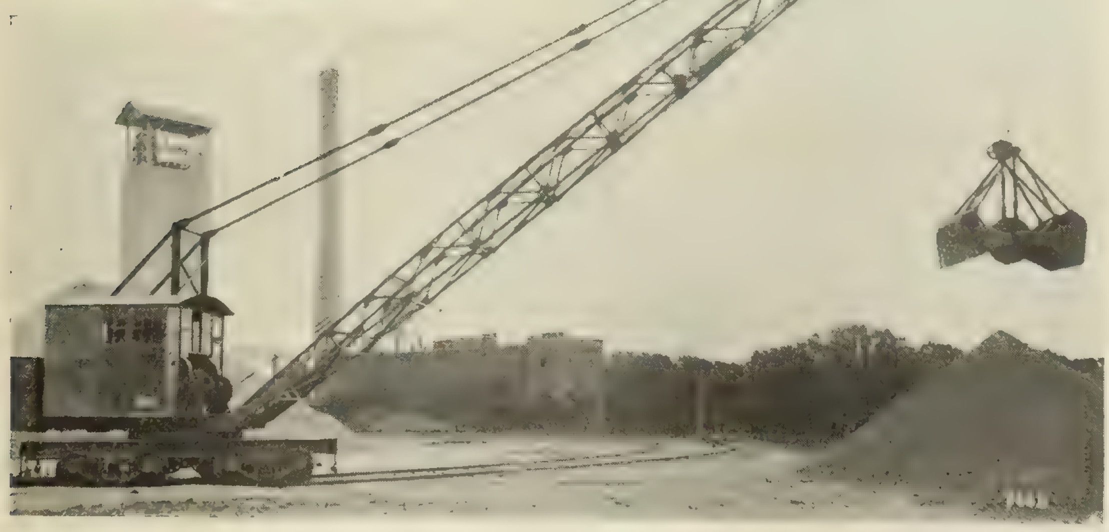


FIG. 1—DIAGRAM OF CIRCULAR STORAGE SYSTEM

FIG. 2—STANDARD GAUGE LINK-BELT LOCOMOTIVE CRANE

The Circular System of Storage for Concrete Aggregate

The most perplexing problem with which the producer of sand and gravel or of crushed stone has to contend is that of storage. Bin space is expensive and it is, in fact, impossible to provide sufficient storage to care for the fluctuating market for the different sizes of material.

The circular storage system[1] which is here illustrated is a patented system designed to be used in connection with long-reach locomotive cranes.

As will be seen by the diagram the material is delivered by cars to a sunken hopper under the tracks. The locomotive crane operating on a circular track takes aggregate from this hopper and distributes it over a very large area, thus providing storage for immense quantities. Various grades can be piled separately and any part of the material is available for loading as orders come in. The illustration shows a standard-guage, eight-wheel locomotive crane equipped with grab bucket. As will be seen from the diagram the crane operates over a 100-ft. radius. This system is said to be in successful use in plants handling sand and gravel, crushed stone, coal and other materials.

Severe Test of Concrete Pipe Joint

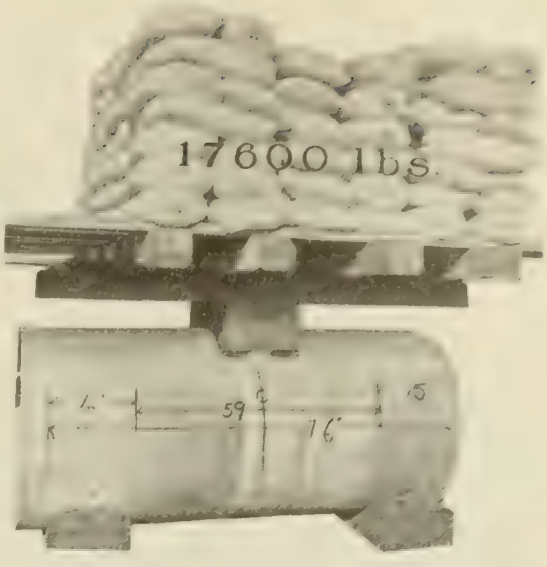


FIG. 1—TESTING A LOCK JOINT AT SAVANNAH, GA.

The favor in which concrete pipe is held by engineers having in charge water supply and sewage disposal problems makes a test recently made in Savannah, Ga., of considerable interest.

Fig. 1 illustrates the method of testing. Two standard 4-ft. lengths of 36-in. sewer pipe were connected by the regular service joint.[1] After curing two weeks they were placed on testing saddles as illustrated and a load of 17,600 lbs. applied.

No deflectometer was used but a string was stretched over blocks inside the pipe, raising it 1″ away from the concrete, and the distance from the string to the joint carefully measured for deflection.

With this loading no cracks developed and no deflection was detected. The pipe are molded with the wire mesh reinforcing projecting and when the pipe are joined the mortar joint is filled from the inside of the pipe, allowing careful inspection.

The Centrifugal Dredging Pump Applied to Production of Sand and Gravel

Until quite recently the centrifugal dredging pump has not been considered very seriously by the contractor for excavating and filling, except in large operations where the equipment for performing the work represented a large amount in investment. It has been but a few years since the pump has to a large extent taken the place of other methods of producing sand and gravel for the building trades.

There are many reasons for the change, notably the adaptability of the pump to conditions which cannot be handled successfully by other methods. For instance, where water is present in large quantities and over a considerable area, a large and ponderous apparatus would be difficult to handle and in danger of upsetting if as close to the edge of the water as would be necessary, whereas a pump being much lighter in weight can be readily placed on a float or barge at small expense and quickly brought in close touch with the operation. The initial cost is very much lower when based on the same capacity. In addition the pumps can be produced with smaller capacities than other types of apparatus, and at such low cost that contractors with a small amount of capital can operate successfully. This applies to small scale production of sand and gravel on a profitable basis.

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[1] The Link-Belt Co., Chicago

[1] Lock Joint Pipe Co., N. Y. C.

It has been found, too, that with ordinary conditions a dredging pump can not only compete with other methods as to cost of production, but can in many cases actually produce at a lower cost.

In the past, it has been the custom to drive dredging pumps either by belt, from a steam engine, or direct steam engine drive, but recently the electric motor has entered this field, and has been found very successful.

Fig. 1 shows a 10-in. Erie[1] dredging pump direct-connected to a 150-h. p. G. E. motor,[2] Two of these outfits were recently placed on barges in the river adjacent to Wichita, Kans., and were used to make a big fill on a railroad in that vicinity. The material to be pumped was very fine, being sand and silt, and a great many obstructions were contained therein as the river had apparently been a dumping place for a great many years. It was quite common for one pump to fill six 30-yd. dump cars per hr. Obviously, this rate could not be maintained throughout the day, as it was necessary to make many shifts of cars, but it does indicate what can be expected under ordinary conditions.

Fig. 2 gives a view of the discharge pipe and how it was supported. The delivery was so powerful that it was necessary to place a length of 16-in. pipe at the end of the 10-in. discharge line to reduce the pressure, and even then, as the illustration shows, a very large delivery was made into the cars.

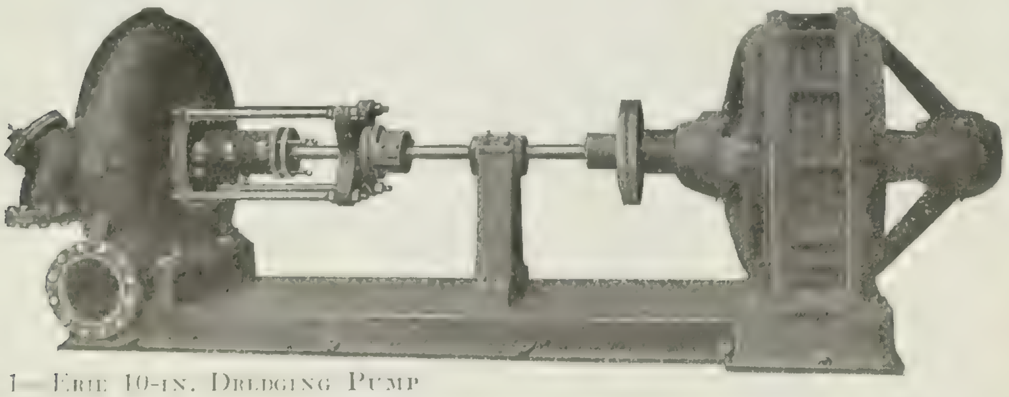


Fig. 1—Erie 10-in. Dredging Pump

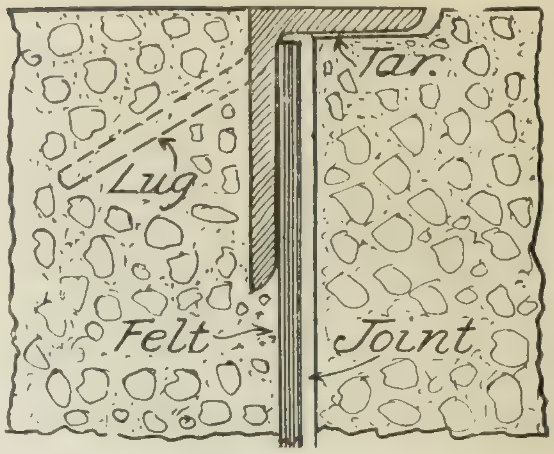
Fig. 2—Discharge of 10-in. Pump Loading Gravel on Cars

Erie Pump & Equipment Co., Erie, Pa.

[2] General Electric Co., Schenectady, N. Y.

A New Road Joint Protector

Experiments with joint protection devices for concrete road work are not yet at an end. A new type has been placed on the market and is being tried out on several roads, streets and alleys in Chicago. This bar has new features. In a way it is a revival of the original idea of an angle iron first used on Wayne County, Mich., road work in 1909. The angle irons were discarded because the broad iron surface did not wear evenly and caused a bump. The new device has a different idea in its use, however. Only one angle is used at a joint, thereby reducing the cost. Referring to the diagram, which shows a longitudinal section of a concrete road with the Universal joint bar[1] in place, it is seen that the bar is placed with the vertical leg bonded to one pavement slab and the horizontal leg projecting out over the other.



Road Expansion Joint Protector

The bond between the concrete and steel is obtained by lugs sheared out of the vertical leg of the angle and bent back 58°. The lugs are spaced 6″ c. to c. Their V shape makes them anchor firmly in the concrete.

In installing the protection bar the entire inside of the angle is first painted with hot tar. While still hot and liquid, a strip of prepared felt (or one or more strips of tar paper), cut to a width equal to the thickness of the concrete pavement slab, is pressed against the vertical leg. As the tar cools it binds the felt firmly to the steel in the required position.

The angles are made of soft steel intended to wear down under traffic at the same rate as the concrete. The vertical leg is $2\frac{1}{2}''$ wide and the horizontal $1\frac{1}{2}''$. Each leg being $\frac{3}{16}''$ thick, the bars weigh about $2\frac{1}{2}$ lbs. per ft.

When the concrete contracts, due to temperature or other causes, the end of one slab slides out a short distance but remains underneath the horizontal leg of the angle attached to the adjacent slab. The only opening formed, into which dirt can penetrate, it at the tip end of the angle and is only $\frac{3}{16}''$ deep. Dirt cannot penetrate horizontally if tar has been properly applied on the lower face of the horizontal leg.

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[1] Universal Concrete Bar Co., Chicago

Concrete

Cement Age

Vol. 7 *Detroit, December, 1915* *No. 6*

The Cement Show

IN an announcement sent out by the Cement Products Exhibition Co. of some of the details of the ninth Chicago Show which will be held Feb. 12-19, 1916, inclusive, it is stated that efforts will be made to induce manufacturers of machinery to make exhibits of the products of their machines. To enable architects and builders to study the possibilities of concrete particular attention will be paid to products. The surface treatment of concrete will be featured and demonstrations of bush-hammering, acid treatment, brushing with water and other methods of treating surfaces will be taught in a sort of school for builders which will be a part of the joint exhibit of 26 cement manufacturers. This is a most important announcement and it should mean a great deal to the concrete field. Many people have realized that the shows in recent years have not by any means come up to their possibilities in developing an interest in concrete construction. This, and other features of the joint exhibit, should help a great deal to attract the attention of architects and builders who heretofore either have stayed away from the shows or who on going to them have not found what they expected to find. The joint exhibit is to mean an investment on the part of the 26 cement companies of about $10,000. It will be an exhibit of concrete products and will occupy the entire south half of the Armory, which is to be used this year in connection with the Coliseum in order to give additional floor space. This additional space amounts to 22,000 sq. ft. The two buildings will be joined by a covered passageway from the rear of one to the rear of the other and there will be entrances to the show on Michigan avenue as well as on Wabash avenue. The decorations will be harmonious throughout the entire show.

The fact that the second National Conference on Concrete Road Building will be held at the Auditorium Hotel in Chicago, Feb. 15-18, will attract a great many road builders. On this account the Cement Show will feature road building equipment to a considerable extent and there will be displays of samples of concrete roads such as will be discussed at the Conference.

Take Care of the Machinery

JUST about now, hundreds of pieces of equipment throughout the country are being laid aside as the result of the coming of cold weather and consequent slackening of construction work. Much of it is being properly housed and cared for, but this condition is by no means universal.

The rush of finishing various jobs and in various ways preparing for winter make easy the neglect of simple precautions which may mean a decided saving of equipment. Some sort of shelter should be provided, at least a shed or a canvas cover, and machinery should not be stored without making sure that it is in such condition that it will not be damaged by rust or frost. Concrete should be carefully cleaned from all parts and fittings removed from boilers and engines. A coat of heavy grease over the metal parts will prevent rusting.

As time permits, each piece of equipment should be thoroughly overhauled, worn or broken parts replaced, boxes babbitted, engines overhauled and put in perfect running condition. It seems needless to point out the fact that the time spent in overhauling and repairing can be given much better now than when spring begins to make demands on one's time with the opening of another season. But there is a tendency to relax and let things go after a strenuous season.

In many cases the general overhauling will reveal the fact that present equipment must be replaced and in such cases it is well to secure the necessary information and if possible decide upon what is to be purchased. This again will save time at a period when time is more valuable.

Concrete Aggregates

THERE are probably very few if any readers of this magazine who will not profit by following closely the series of articles, on "Concrete Aggregates," by William M. Kinney and Duff A. Abrams, beginning in this issue. For some readers this series will serve merely to emphasize much of what they probably already know, yet the amount of work which is being done all the time in which proper attention is not paid to the selection of suitable aggregates points out the necessity of just such emphasis. This material by Messrs. Kinney and Abrams covers the subject of Concrete Aggregates most thoroughly—more thoroughly, probably, than has ever before been accomplished in a single treatise. What they have set down in these articles they do not hesitate to say does not represent the last word upon the subject, because on such an important topic the last word will probably not be said for many years to come. There are a number of important technical committees at work even now upon the subject of aggregates. It is not likely that their labors will be completed for a long time. In the meantime it seems desirable to have stated as exhaustively, yet as briefly and compactly as possible, the sum of knowledge to date on what is best practice in the selection and use of concrete aggregates. This series which is begun in this issue will undoubtedly meet the requirements of the field.

The Perils of the Wood Shingle

A RECENT issue of the Salem *News* names 13 reasons (compiled by a local insurance man) responsible for the great conflagration. After stating that the cause of the fire was the storage of highly combustible material in an obsolete building and naming the peculiar local combination of circumstances responsible, he states as reason number seven "The broad area of shingle roofs exposed to sparks and brands was the most important contributing cause of the wide spread of the fire." As has been already noted in this magazine Salem does not now permit the use of wooden shingles.

The Wood Cornice Unsafe

IN the conflagration at Salem, Mass., it was observed that, next to the shingle roof, the wood cornice was the most vulnerable part of a building. Fire was communicated to the side of a house and quickly burned through the under side of the light frame cornice which almost invariably was not fire-stopped and thus communicated directly with the interior of the building. This method of fire spreading was so pronounced that in drafting new building ordinances the city of Salem absolutely prohibits the use of unprotected wood as a cornice material.

All cornices must now be metal covered or constructed of non-burnable material. Wood protected by sheet metal is largely used and cement stucco on metal lath is also finding much favor and seems to be a particularly logical treatment in connection with buildings of concrete or frame and stucco. It is also an economical construction, particularly where cornices are wide, as is the present tendency in residence architecture. A metal gutter with a metal covered fascia in connection with metal lath and stucco soffit is readily constructed and looks and wears well.

Help (Intelligent) Wanted

IMPORTANT as is the cement which goes into concrete and important as are the aggregates with which the cement is to be mixed, there is an increasing amount of evidence that, after all, the most important factor in the concrete field is the men. Men with adequate technical knowledge and with adequate practical knowledge who can apply what they know *efficiently* in the concrete field are always in demand. Nowhere is there greater lack of such men than in the manufacture of concrete products. This magazine has frequently had occasion to mention that in the early days of concrete block manufacture the apparent ease with which the work could be done attracted incompetent men to that industry. It was only when it was discovered that there were real problems in the work, real difficulties to be overcome, and real rewards for those who overcame them, that really good men got into the business. These able men in administrative positions are now frequently having hard work to get men into their business who can carry on detailed work of various kinds. Under competent supervision, ordinarily intelligent labor can be used in the molding department and in the yard work, while a higher degree of intelligence is required in proportioning materials and in operating the mixer, etc., but the place where men of ability are most needed is in other departments of concrete products manufacture. Only recently the attention of this magazine was called to the fact that one very large manufacturer of concrete stone is seriously handicapped for want of draftsmen with the special skill required in laying out detailed drawings of dimension stone so that the men in the modeling department and the pattern shop can get out the proper models and molds. There is further difficulty in getting the proper men in the modeling department and in the mold-making department—men who understand enough about the work to make a mold so that the stone will draw after it has been cast. Every piece of stone which is at all intricate in its design is a new problem and real intelligence is required in handling the work of making the molds. The fact of the matter is there is such a dearth of competent men in these lines of work that some manufacturers are actually running schools in their factories to train the men for future good service. With a few good men to supervise what the "students" are doing, the work is going on along the line of a training school trying to produce men who can later do the specific work required of them in concrete stone manufacture. It is to be hoped that it will become more and more apparent to men whose basic training fits them to take up something along these lines that there is excellent opportunity for them to specialize for real competent service in the manufacture of concrete stone.

Curing Concrete Stone Under High Steam Pressure

ADOLPH Schilling, manager of the Pompeian Stone Co., Haddon Heights, N. J., recently purchased a sand-lime brick plant and is making use of the cylinders in conducting tests of high pressure steam in curing concrete. He is going to try to put to some commercial account what thus far has been a laboratory proposition only. He proposes to use pressure up to 120 lbs. He reports that he has made some 1:3:5 mix bricks; cured them under this high pressure steam and was able to tool them under carborundum wheels at the age of 4 das. These same bricks showed only 5% of absorption. The cylinder being used by Mr. Schilling is 70′ long and 6′ in diam. and it is possible to use it for tests up to 150 lbs. pressure. Mr. Schilling has been using aggregate in his tests consisting of flint pebbles and silica sand.

When putting clips on wire ropes be sure that the saddle of the clip is placed on the main rope and the U on the short end.

The saddle grips the rope much more securely than the round iron and should invariably be placed so as to take the heaviest strain.

Concrete Aggregates: Classification, Sources, Physical Condition, Requirements

By William M. Kinney[1] and Duff A. Abrams[2]

This is the first of a series of articles, or is probably better described as Part 1 of a thorough and comprehensive treatise on the subject: "Concrete Aggregates." It is the most important material from the standpoint of its probable value to the concrete industry as a whole, which this magazine has been able to offer you in a long time. No one doing Concrete work can fail to find immediate and constant application to his work for the material in this series. Suitable aggregates are a fundamental consideration for good concrete.

The second part will be published in the Feb., 1916, issue.

INTRODUCTION

Concrete differs from all other structural materials in that it is not a finished product until several weeks after it has reached its final place in the structure. Other structural materials are either provided by nature or are finished in a plant where rigid inspection of all processes is posssible.

In the manufacture of concrete it has been the practice in the past to give particular attention only to the cement which is used in the mix. However, the more progressive engineers are beginning to note that in a large proportion of the instances of defective or inferior concrete the fault is due to the quality of the aggregate materials which were used. Due to the continuous inspection of the processes of manufacture, the cement which is turned out at the present time may generally be considered to be of a high grade. When it is considered that the cement is only about 20% of the entire material used in concrete it seems apparent that the aggregate material should receive a considerable share of attention.

Portland cement is now being manufactured by about 120 different plants in the U. S. We may safely say that the plants and deposits from which concrete aggregate materials are obtained are numbered by the thousand, and that hundreds of new deposits are being utilized each season. This would suggest that considerable care should be given to the selection of aggregate materials and that rigid standards should be devised for determining whether or not the material is acceptable for a given purpose.

The present state of perfection in the manufacture of Portland cement may be said to be due largely to the fact that definite specifications and methods of tests have been in force for a great many years. At the present time there is a great diversity of practice in the selection and use of aggregate materials. On account of the fact that these materials cannot be transported for long distances, it is essential that materials which are close at hand should be used if concrete work is to be economically carried out. Due to this cause a very great variety of materials has been used for concrete aggregates.

A large number of tests on the effect of the grading of sands, etc., on the strength of cement mortars have been carried out by Feret, Candlot and other Europeans, and by Thompson, Fuller, Lesley and other American investigators. Thus far no sustained effort has been made in this country to determine the relative concrete-making qualities of the various fine and coarse aggregate materials which are available and commonly used. It has long been recognized that the presence of certain impurities in aggregate materials would result in defective concrete. However, the exact nature of this influence has not been studied nor the causes for it definitely established.

A considerable amount of experimental work with sands and other aggregates was carried out at the Structural Materials Testing Laboratory of the U. S. Geological Survey at St. Louis. The results of these investigations have been published in U. S. Geological Survey Bulletin No. 331, on *Portland Cement Mortars and their Constituent Materials.*

A state-wide aggregate survey of the State of Wisconsin is being carried out at the present time under the direction of Prof. M. O. Withey, of the University of Wisconsin. Considerable work on the study of local sands has been done by the Public Service Commission of N. Y. C.

A committee of the Am. Soc. for Test. Mat. was formed about a year ago for the purposes of reporting on standard specifications and methods of tests for concrete and concrete aggregates. This committee is endeavoring to carry out a thorough investigation on the subject with a view to securing information upon which the necessary recommendations may be based. It seems that specifications and standardized tests of concrete aggregates would have an important influence in bringing about a better understanding of the requirements of these materials in order that a high grade of concrete work may be done at a minimum cost.

Most of the earlier experiments of the quality of fine aggregate for concrete have been based on results obtained from tension tests of briquettes of the standard form which have been in use for many years in testing cements. However, more recent investigations have shown that these results are of questionable value. The authors are thoroughly convinced that many of the conclusions concerning the requirements for sands for concrete which were found in the text-books are entirely erroneous, due to this cause.

The wide-spread use of concrete as a wearing surface for roads and pavements has served to indicate further the need for more complete information concerning concrete aggregates. The severe service to which any pavement surface is subjected makes it essential that none but high-grade materials be used for this purpose. This emphasizes the necessity for determining in advance of use whether or not a given material is suitable, or which of several available materials is best.

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[1] Engineer, Information Bureau, Universal Portland Cement Co., Chicago.

[2] Instructor in charge, Structural Materials Laboratory, Lewis Institute, Chicago.

The Committee on Resolutions of the National Conference on Concrete Road Building deemed the subject of aggregates of such vital importance as to conclude its report as follows:

> Whereas, the quality of the sand, gravel and stone available for use in concrete in the various localities in each state is of fundamental importance and has not yet been extensively determined; therefore be it
>
> Resolved, by the National Conference on Concrete Road Building, assembled in Chicago, Feb. 12, 13, 14, 1914, that it is highly desirable that the materials available in the various states for use in concrete should be examined and tested as rapidly as possible by competent state Geologists, Universities or Engineering Experiment Stations, and be it further
>
> Resolved, that the Governor and the Legislature of the several states be provided with a copy of these resolutions, and asked to seriously consider the great necessity for making adequate provision and appropriation to the proper agency for the prompt inauguration of such investigations.

Test methods are now being developed which it is hoped will enable us to secure a definite measure of the quality of an aggregate. However, a renewed interest has been created in the whole subject of selecting, grading, proportioning, etc., of concrete aggregates and we are further impressed with the great importance of a comprehensive experimental study of the entire problem.

Within the last few months complete series of tests have been carried out on about 2,000 different samples of sand and other fine aggregates at the Structural Materials Research Laboratory, Lewis Institute, Chicago. For most of these samples, in addition to the tensile tests on cement-sand mortars, compression tests were made on the mortars, and in a large number of instances compression and other tests of concrete were made also. It would seem apparent that the concrete tests furnish the best criterion as to the concrete-making qualities of a sand or other aggregate material. The methods developed in carrying out these tests and the results of the investigations will be drawn upon in the discussions presented in the following articles, in this series.

It is the purpose of these articles to review, in a non-technical manner, the subject of concrete aggregates in the light of our present knowledge to the end that renewed attention may be called to the importance of exercising the proper care in selecting and testing these most important ingredients of concrete.

CLASSIFICATION OF AGGREGATES

Concrete aggregates are usually classified as fine and coarse, according to the sizes of particles. Fine aggregate is almost universally defined as that portion of any suitable material which will pass a sieve having $\frac{1}{4}$-in. meshes, while that portion retained on the screen is considered as coarse aggregate.

A concrete of fair quality, if rich enough in cement, can be made with many kinds of mineral aggregates; but there is, nevertheless, a wide variation in the results produced. Sand, or stone screenings, may be used as fine aggregate. For coarse aggregate, crushed stone, screened gravel, blast furnace slag, crushed lava, shells or mixtures of these may be employed.

The fact that so wide a range of materials may be used in making concrete, every one of which really consists of a large class in itself, varying in size, shape and composition, tends to blind one to the economies which may result from careful selection and proportioning of aggregates for concrete.

The bare fact that an aggregate may look fairly good and still be totally unfit for the work in hand makes study and careful tests necessary if the best results are to be expected. The idea that the strength of concrete depends entirely upon the cement and that only a superficial examination of the other materials is necessary, is altogether too prevalent.

Experience has shown that in general greater care must be exercised in selecting a fine aggregate than in the case of a coarse aggregate. On account of its finely divided state a natural sand may carry a considerable amount of impurities which would escape notice unlesss most careful tests are made. In these articles particular attention will be given to a detailed discussion of five aggregates.

SOURCES OF SUPPLY

Broadly, the materials in most common use as concrete aggregates in different places throughout the United States are the sedimentary rocks, which may be grouped into three classes on the basis of origin: (1) glacial deposits, (2) costal plain deposits, (3) stream deposits. The deposits of the first and second classes have, in many instances, been modified by water action, and the third class may be considered as composed partly of materials derived from deposits of the first two classes and partly of materials derived directly from the breaking down of the original igneous rock. All three classes of deposits contain more or less silt, clay, loam or other very finely-divided impurities.

Distribution of Gravel—The gravel beds of the glacial drift furnish excellent material for concrete. "The glacial ice sheet, often a mile or more thick, covered New England and Canada and all of the U. S., north of an irregular line starting on the Atlantic Coast a little south of N. Y. C., and running thence successively to the southwest corner of the state of New York, to Cincinnati, to a point a little north of the mouth of the Ohio River, to the mouth of the Missouri River, to Topeka, Kans., thence north and west a little west and south of the Missouri River to the head waters of that stream, and thence west to the Pacific Ocean. All of the area north of the above described line was covered with the ice sheet, except small portions of southeastern Minnesota, northeastern Iowa, northwestern Illinois and a considerable portion of southwestern Wisconsin. As this ice sheet crept to the southward, it rent great quantities of stone from the bed rocks; and these materials were borne southward, either in the slow-moving ice or hurried along by the violent currents of water which swept forward to the margin of the ice field. Thus impelled the under-ice streams were able to bear toward the margin of the glacier great quantities of stone. The original range of the glacial gravels has been greatly extended here and there by the streams, which, flowing southward beyond the drift belt, have often carried quantities of the hard detritus for many miles beyond the limits of the ice field.

"Glacial gravels exist in considerable quantities in western Pennsylvania, in the greater part of Ohio, in northern Indiana, and in northern Illinois, and to some extent in several of the states of the Northwest." There are large areas of this gravel in Wisconsin, Minnesota and Iowa.

"South of the glacial district, the rocks exposed to the weather have decayed by a process of leaching, which in many instances have removed strata hundreds of feet thick. The rock portion is removed in proportion to its solubility, and as a result, there are often left concretions of cherty matter, which were originally contained in beds of limestone. This cherty residuum of flinty material generally lies in a comparatively thin sheet of fragments mingled with sand and clay; but occasionally it is found in deposits from which the clay and sand have been removed by recent or ancient streams[3]."

PHYSICAL CONDITIONS

The various fine aggregates, or sands, differ not only in chemical and mineralogical composition, but in physical condition as well. Often many impurities are present, the effect of which should be known as well as the methods for determining their presence.

Impurities—Many of these substances have an injurious effect upon the setting properties of the cement, and hence upon the strength of the concrete. As examples of such substances, the following may be mentioned: Clay or loam, if present in any quantity, such as often occurs with pit sand, and with that obtained from the beds of sluggish streams; peat and other vegetable matter.

Much has been written as to the effect of clay upon concrete and many diametrically opposite opinions have been advanced. Certain points, however, are fairly well agreed upon by engineers. Clay, when it exists as a coating on the particles of sand aggregate, is undoubtedly injurious, as it prevents a proper adhesion of the cement to the surfaces of the sand. When, however, clay of a siliceous nature exists to a small extent throughout the mass of the aggregate, in the form of separate particles, it appears to cause no serious harm in many kinds of concrete work. Although clay in this form acts as an adulterant, some writers have held that as much as 5% to 10% may be admitted without seriously reducing the strength of the concrete. Their conclusions, however, are based largely on the results of tensile strength tests, in which relatively dry mixtures have been used. It is doubtful whether under field conditions or even in large compression test specimens made up in the laboratory this same conclusion would be sustained. The very thorough mixing that mortar for tensile test specimens receives in the laboratory so completely incorporates the clay in the mixture that the usual effect is lost. In most cases, the mixtures used are relatively dry and the slower hardening usually noticeable where an excess of clay is present, would be an advantage rather than a disadvantage, preventing small specimens from drying out too rapidly to the disadvantage of their strength. Then, too, an excess of clay has a tendency to deceive those who are examining the concrete into believing that it contains an excess rather than a shortage of cement. The principal advantage that seems to result from the presence of clay is that it increases the density of lean mixes of concrete by filling some of the voids.

The methods of determining the amount of clay and a further discussion of its effect will be found in a later article in this series.

Organic Matter — There is no doubt as to the injurious nature of organic matter or loam contained in the aggregate. Organic matter in sand is often indicated by the presence of roots, by the "dead" appearance of the sand in drying out in the pile, and by a coating of dust on the grains which can often be detected best by the use of a magnifying glass.

Vegetable Matter—Vegetable matter coating the grains appears to prevent the cement from adhering to the aggregate, and also to affect it chemically. Frequently an amount of impurity so small as to be impossible of detection by the eye and showing up only slightly in chemical tests, may be sufficient to prevent the mortar from reaching any appreciable strength. Usually concrete made with such sand hardens so slowly that the presence of the impurities may be detected in this way.

Whether the undesirable results are due entirely to chemical action or in part to mechanical action, has not been determined. In all probability the action is chiefly chemical. The subject appears to be of sufficient importance to warrant thorough investigation.

Other impurities or foreign substances, such as acids, alkalies or oils contained in the sand or mixing water usually make trouble.

About the only way to be sure of the quality of a sand is to test the strength of the mortar made from it in proportions of one part cement to three parts sand, and compare the results with the strength of a like mortar made with the same cement and standard Ottawa sand.[4]

A usual requirement of sand specifications is that the strength of the concrete sand tested in this way shall be equal or greater than that of Ottawa sand in a 1:3 mix. This sand should give a strength equal to 130 to 150% of that of standard Ottawa sand in a 1-3 mix. This subject will be discussed in greater detail under "strength tests" below.

Effect of Moisture—Moisture in sand is not objectionable except for the reason that it makes proper proportioning with the other materials more difficult. This is discussed under the analysis of sands and proportioning of the aggregates.

GENERAL REQUIREMENTS

The various properties of concrete are affected by the hardness or crushing strength of the aggregates, their durability or resistance to weather, grading, or maximum and relative sizes of particles, cleanness or freedom from foreign materials, and the shape and nature of the surface of the particles.

Hardness—The hardness of the material grows in importance with the age of the concrete. Owing to the rounded surfaces of the aggregate gravel concrete one month old may be weaker than a concrete made with comparatively soft broken stone; but when one year old it may surpass in strength the broken stone concrete, because as the cement becomes harder and the bond firmer the resistance of the aggregate to shear under stress becomes a more important factor.

The grains should offer as high a resistance to crushing as does the cement after attaining its maximum strength. Generally speaking, concrete cannot develop strength greater than the strength of the aggregate from which it is made. It is not uncommon to find in compression test of sand mortars that at ages of 6 mos. or more the sand particles are sheared or broken off instead of being pulled out at failure.

Durability—The ability of rock to resist effectively varied weather conditions is a very necessary quality. This concerns the texture and mineralogical composition of the material. The presence of feldspar, mica, hornblende, etc., in trap and granite does not appear to be especially detrimental to their weathering properties, but the opposite usually holds true when these minerals occur in gneisses, probably due to the different manner in which they are contained. Good structural rocks should not show any cracks, small seams or intermixture of foreign substances. The presence of foreign substances is usually indicated by discolorations of the material.

The presence of a small percentage of metal, such as copper, nickel and iron, as well as sulphur, in the aggregate, has been known to result in the disintegration of the concrete. This has been attributed to the formation of the sulphides and other unstable compounds by the action of moisture on the rocks which contained the metals, the chemical reaction being of such force as to break up the concrete.

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[3] The quotations are from Baker's *Roads and Pavements*, John Wiley & Sons, Inc., N. Y. C.

[4] Standard Ottawa as recommended by the Committee of the American Society of Civil Engineers is a natural sand from Ottawa, Ill., screened to pass a sieve having 20 meshes per lin. in. The amount of voids in this sand is about 37%.

Values of Different Rocks—Different rocks of the same class vary so widely in texture and strength that it is impossible to give their relative values as aggregate. However, a comparison of a large number of tests of concrete made with different kinds of rock material indicates that the value of a broken stone as an aggregate is largely governed by the actual strength of the stone itself, the hardest stone producing the strongest concrete.

Comparative tests discussed by various writers indicate that different materials stand in the following order as regards their value for concrete aggreate: (1) Granite, (2) Trap Rock, (3) Gravel, (4) Marble, (5) Limestone, (6) Slag, (7) Sandstone. An approximate estimate drawn from comparative tests given the value of good sandstone as not more than two-thirds the value of granite for concrete aggregate.

These values are based on compression tests. Wear tests such as that to which a concrete pavement is subjected may show different values.

The grading or relative size and quantity of the particles of an aggregate, determines, in large measure, the density of the mass, which in turn greatly affects the quality of the concrete. A coarse, well-graded aggregate produces the denser and therefore the stronger concrete or mortar. A sufficient quantity of fine grains is valuable to grade down and reduce the size and percentage of voids. For leaner mixtures a small addition of fine particles may be found advantageous in assisting the cement to fill the interstices between the particles of coarse aggregate but has the tendency to diminish the compressive strength considerably. (Note further reference to grading in a later chapter.)

A good rule to follow in proportioning aggregates to produce dense concrete is to have the parts of fine aggregates equal half the sum of the parts of cement and coarse aggregate, as 1:2:3, 1:2½:4, etc. The use of these proportions presupposes that the aggregate has been carefully screened so that it is free from material that would pass a ¼-in. sieve. If there is any of this finer material, mixed with the coarse aggregate, which very frequently is the case when materials are screened wet, proper allowance should be made, and the amount of fine material reduced to take care of the difference; otherwise there will be a tendency to reduce the strength of the concrete materially, because of the excess of fine material in comparison with the quantity of cement.

To carry through the principles of proper grading of materials, not only should both the fine and coarse aggregate be properly graded, but they should be combined in proportions which will result in the total combination of materials being properly graded. For this reason the practice of arbitrarily specifying the proportion of materials, fine and coarse aggregates, is poor, especially when little or nothing is known of the physical properties of either material. It is generally desirable to specify the richness of the concrete in cement, but for important work the proportioning of the fine and coarse aggregates should always be preceded by a direct study of their proportioning with a view to securing a concrete of maximum density. This subject will be discussed in detail in a later issue.

Weight and Voids—A high unit weight of material and a corresponding low percentage of voids are indications of coarseness and good grading of particles. However, the absence of uniform methods of weighing and measuring makes these results merely general guides which cannot be considered conclusive in the absence of other evidence.

On account of these discrepancies, it is better to mix the sand with cement and water, and determine the density of the fresh mortar, if accurate determinations are desired. The mortar having the highest density, with a given amount of cement, that is, the lowest "air plus the water" voids, is the best.

Shape of Particles—The shape of the rock particles determines to some degree the strength of the mortar or concrete. A flat material that packs less closely and offers less resistance to cross-breaking stresses is generally inferior to material composed of particles of cubical fracture.

Maximum Size—Up to a reasonable limit, the strength of concrete increases with the size of the aggregates, provided the material is well graded from fine to coarse. For mass concrete a practical maximum size is 2½″ or 3″. In thin walls, floors and other reinforced construction the size must be such as can be worked readily about the reinforcing metal.

Cleanness—The particles of rock should be free from dirt and dust, and should not be used even when partly covered with clay. These impurities prevent the cement from obtaining a bond on the surface of the particles and often contain materials that retard the hardening of the concrete and prevent it from acquiring normal strength within a reasonable length of time.

An excess of clay or dirt in any form also affects the color of the mortar when set, requires more thorough mixing with the cement, and weakens the mortar.

Surface of Particles—Primarily, the surface of the rock particles should be free from foreign material. If the surface of the material is rough, that is, "gritty," the cement should obtain a better early bond, but this condition is less necessary as the age of the concrete increases, except that the use of a "flint" rock with polished surface would hardly be advisable.

"Sharpness"—In giving the general requirements for a good concrete sand, nothing has been said of "sharpness," and the omission was intentional. Too many specifications have contained the word "sharp" when neither the author nor the reader of such specifications could clearly define the term as being applicable, or predict its effect. Angular sands present a greater percentage of voids than those of rounded grains, and accordingly suggest less strength. A sand with a "gritty feel" may be classed as being of a siliceous nature, with no excess of fine material, and there in lies the only excuse for recommending a "sharp" sand. The tests seem to indicate that sharp sand may give higher values when tested at 7 das. or 28 das, but that for older mortars and concretes the advantage is in favor of a rounded sand. A sharp angular sand would be open to the same objections as a coarse aggregate compound of flat particles, namely: the particles offer less resistance to shearing and cross-breaking stresses, hence permit failure, at a lower stress than do spherical particles. The adhesion is generally sufficient in any case.

The tendency of railroad improvements is toward permanent concrete structures for bridges, viaducts and similar structures. With the best engineering advice, and careful men and with the most expert data from the widest experience in the use of concrete, the railroads have found that their investments in concrete pay better than any other.—*Rock Products.*

Design Methods in Concrete Construction—Arches With Fixed Ends

By A. M. Wolf, C. E.[1]

This is the second part of Mr. Wolf's article on Arches with Fixed Ends (in the series, "Design Methods in Concrete Construction" begun in the Jan., 1915, issue). The first part was published last October. It has been found necessary further to divide the matter and a third part will appear in a later issue.

STRESSES IN REINFORCED CONCRETE ARCH SECTIONS

The formulas (11 to 15, incl.) given in Part I do not apply to the stresses in reinforced concrete sections subjected to bending and direct stress, since the materials making up the section are not homogeneous and do not possess the same elasticity. The ratio of the modulus of elasticity of steel, E_s, to that of concrete E_c, usually known as n, is generally accepted as *15*, or for well hardened concrete as *10*. Therefore, in order to simplify matters, the steel in compression may be replaced by an equivalent area of concrete by multiplying the steel area by n. The moments of inertia can be similarly compared and the section, then called the transformed section, treated as one of plain concrete, the location of the center of thrust determining, as before, the stress distribution.

Using formula *12* as a basis and substituting the area of the steel as equivalent concrete, the unit stress in the section at any distance c from the gravity axis equals

$$f = \frac{N}{A_c + nA_s} \pm \frac{Nec}{I + nI_s} \quad (16)$$

or simplifying

$$f = \frac{N}{A_t} \pm \frac{Nec}{I_t} \quad (16a)$$

in which equations

A_c=area of concrete section.

A_s=total area of steel.

I_c=moment of inertia of concrete about the central axis of transformed section$= \frac{bh^3}{12}$

I_s=moment of inertia of steel about the same axis$=A_s\,(\frac{1}{2}\,h-d^1)^2$ if the steel is symmetrically placed about the central axis, that is, the same amount in top and in bottom equally distant from the central axis.

A_t=area of the transformed section$=A_c+nA_s$.

I_t=moment of inertia of the transformed section$=I_c+nI_s$.

This general formula *(16a)* applies for compression over the entire section, or for compression on a part and tension not to exceed the allowable for the concrete, in general 50 lbs. per sq. in.

For maximum compression in the concrete, c_1 (Fig. 10) being the distance to the most extreme fiber from the gravity axis on the side of same on which the thrust acts,

$$f_c = \frac{N}{A_t} + \frac{Nec_1}{I_t} \quad (17)$$

The minimum compression in the concrete on the side of the gravity axis opposite that on which the thrust acts, will be

$$f'_c = \frac{N}{A_t} \quad \frac{Nec_2}{I_t} \quad (18)$$

where c_2 equals the distance from the gravity axis to the extreme fiber of concrete on the side of the axis in question.

The maximum compression in the steel will, of course, occur on the same side of the gravity axis as the maximum compression in the concrete. Letting c_3 equal the distance from the gravity axis of the section to the center of gravity of the steel on the side on which the thrust acts,

$$f'_s = n\left[\frac{N}{A_t} + \frac{Nec_3}{I_t}\right] \quad (19)$$

the stress in the steel on the opposite side of the gravity axis is given by

$$f_s = n\left[\frac{N}{A_t} \quad \frac{Nec_4}{I_t}\right] \quad (20)$$

When the eccentricity, $e=O$, that is, when the thrust acts at the center of gravity of the section, there is no moment, but direct stress only, and the second terms involving the eccentricity drop out of equations 16 to 20, inclusive, and the compression in the steel or concrete is the same at either side of the axis.

Let us now consider that the thrust acts at some point away from the gravity axis such as to make the compression on the extreme fiber on the opposite side of the axis, zero. For a plain concrete section this condition is reached when the thrust acts at the outside point of the middle third, that is, when $e=\frac{h}{6}$. Due to the presence of the reinforcement at some distance d^1 in from the extreme fiber of the section the eccentricity which will produce zero stress at one extreme fiber is of necessity somewhat greater than $\frac{h}{6}$, that is, the thrust N may act at some small distance outside the middle third without producing tension in the section (see Fig. 10). Letting this value of eccentricity be known as e_0, we have

$$e_0 = \frac{h^2 + 12np'a^2}{1 + np'} \times \frac{1}{6h} \quad (21)$$

in which p^1 equals the ratio of the total area of steel to the total area of the section.

Now if the eccentricity is greater than the value found by equation 21, the concrete is in tension (see Fig. 10). If this tension is small, say less than 50 lbs. per sq. in., for the most severe condition of loading, considering also temperature and rib-shortening stresses, then the various fiber stresses can be computed by the formulas just given.

It is the usual practice, however, in the design of concrete structures to neglect entirely the tensile value of the concrete. In arch design, if the tensile stresses in any section as computed by formulas 16 to 20 exceed the value just given, the stresses should be recomputed by the following formulas. These are derived not by the use of the transformed section, but by a method similar to that used in simple flexure, which is the easiest of application. The formulas are based on the use of symmetrical reinforcement placed so that $d^1/d=\frac{1}{10}$ (see Fig. 10).

The compression in the concrete can be found by the equation

$$\frac{Ne}{bh^2f} = \frac{1}{12}k(3-2k) + \frac{2pn}{k} \times \frac{a^2}{h^2} \quad (22)$$

where p is the ratio of area of steel in one face to the area of the entire section, and k is the ratio of the depth of neutral axis to the depth d.

The compressive stress in the steel,

$$f'_s = nf_c\left(1 - \frac{d'}{kh}\right) \quad (23)$$

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[1] Prin. Asst. Engr., Condron Co., Chicago.

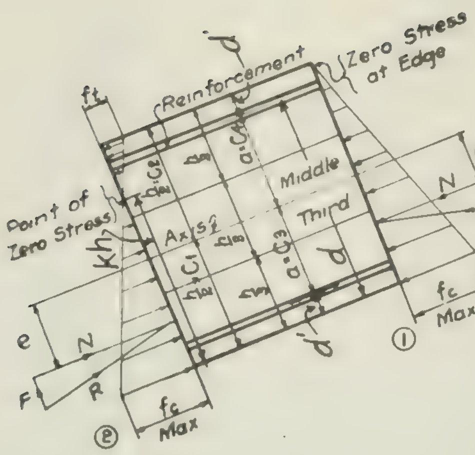


Fig. 10—1. Force Acting at a Distance from Gravity Axis Such as to Give Zero Stress at Outside of Section. 2. Force Acting at a Distance Greater Than e_o from Gravity Axis, Producing Tension on Outer Portion of Section

and the tensile stress in the steel,

$$f_s = f_s' \frac{(1-k)h-d'}{kh-d'} = nf_c \frac{(1-k)h-d'}{kh} \quad (24)$$

The following table gives some values of k for different values of p with $n=15$:

p	k
0.01	0.32
0.015	0.387
0.02	0.41
0.025	0.46

Other values of k can be found for any value of p, by the formula

$$k - \sqrt{2n(2p\frac{d'}{d}) + [n(2p)]^2} - n(2p) \quad (25)$$

THE ELASTIC THEORY OF CONCRETE ARCHES

General—An arch with fixed ends, commonly known as a hingeless arch, is a statically indeterminate structure, that is, it cannot be analyzed by the ordinary methods of statics. Therefore, to find the true resistance line in a fixed end arch by the static method, as previously outlined in Part I, it is necessary to assume points of application for the resistance line at the crown and the springing lines and make such other approximations as are necessary to eliminate enough of the unknowns to permit the solution of the problem. In analyzing an arch by the method of the elastic theory the location of the true line of resistance is found without resorting to such approximations.

In applying the elastic theory the following assumptions are basic:

1. The material is elastic and obeys Hooke's law.
2. The modulus of elasticity of the material is constant, that is, the material is homogeneous.
3. Loads cause no change in span length.
4. The arch is fixed at the abutments, or, in other words, that a tangent at these points remains unchanged in direction.
5. The abutments are unyielding, that is, the ends remain in the same horizontal plane under all conditions of loading.

From the preceding it is evident that unless the assumptions made are fulfilled, correct results cannot be obtained by the use of the elastic theory. It is also important to note that the proper design of piers and abutments is one of the most essential requirements. If assumptions 4 and 5 cannot be complied with, a three-hinged arch should be used, since it readily adjusts itself to any slight deformation or yielding of the supports.

Tests made by Prof. M. A. Howe show that the results obtained by the use of formulas based on the elastic theory check closely with experimental results. Also that the elastic theory can be used with confidence just so long as no tensile stresses occur in the arch ring, in which case the theory under the usual assumptions is only an approximation. For this reason it is the usual practice to proportion plain concrete arches and also those of reinforced concrete so that the stresses are entirely compressive, except for reinforced arches, where a small amount of tension is often allowed in the arch ring under a combination of stresses due to temperature variation, rib-shortening, with those due to dead and to live loads. In such cases the maximum compressive stress on the section should not exceed 800 lbs. per sq. in.; the concrete on the tension side may crack and the steel resist all the tensile stresses.

The analysis of an arch by the elastic theory consists in first determining the thrust, shear and bending moment at the crown; and then from these compute the values of thrust, shear and bending moment at other sections of the arch. This analysis can be carried out entirely by algebraic methods, but the work is considerably simplified by the use of some graphical methods and they are accordingly treated in this article, along with the algebraic methods. An arch ring of the desired, or most economical curve, with sections as determined by the empirical formulas in Fig. 5, Part I, is first laid out and subjected to exact analysis and the design corrected in accordance with the results obtained and analyzed again if the corrected design varies much from the preliminary.

METHOD IN DETAIL

The following detailed exposition of the procedure gives the various steps, taken in order, for the complete design of an arch by the elastic theory:

1. *Preliminary*—A profile of the site of the proposed bridge should be made, showing depth and character of foundation and overlying soil. Upon this locate the piers and abutments with reference to sufficient waterway, economical foundations and roadway. After locating the piers, select the most economical type and curve of arch for the span and rise determined upon, in accordance with the principles laid down in Part I.

The preliminary arch ring is then laid out with a thickness at crown and spring as determined by the empirical formulas and the theoretical span and rise of the arch axis are determined.

2. *Subdivision of Arch Ring for Constant* $\frac{\delta s}{I}$—For the purpose of analyzing the arch ring and computing stresses at various points the ring is divided into an even number of divisions, usually 10 or 20, depending on the span length, so as to make the ratio $\delta s : I$ constant, where δs equals the length of section and I the moment of inertia of the cross section.

If the arch is to be reinforced the moment of inertia I should take this into consideration and will equal

$$I_t = I_c + n\ I_s$$

that is, the moment of inertia of the transformed section should be used. In order to arrive at the moment of inertia of the steel it is, of course, necessary to assume some amount of reinforcement for the purpose of computation. In general, this should be taken as from 0.7% to 1.5%, depending on the span and the loading.

If the concrete only is considered it can be seen that the moment of inertia will increase as h^3, so that a small change in depth will cause a large change in moment of inertia. In order then that $\delta s/I$ be kept constant the value of δs at the crown must be smaller than at the springing line, since the depth of arch ring h, in general, increases from crown to springing line, and to secure accuracy the crown division should be made fairly short.

The value of $\delta s/I$ to use so that no fractional divisions occur can be determined algebraically as follows:

Let $i = \frac{1}{I}$; i_a = mean or average value of i.

s=half length of arch ring measured along the axis.

n=desired number of divisions in one-half arch.

Complete values of i at several points on the half arch at equal intervals and then obtain the average value i_a, with which we find

$$\frac{\delta s}{I} = \frac{s i_a}{n} \quad (26)$$

from which equation after computing the value of I for each section, the proper length of δs for various divisions can be found, beginning at the crown and working toward the springing line. Since the length of the divisions is not known at the start the value of I, which should be the average for the division, will not be exact, but this can be readily adjusted after the first trial computations.

A graphical method of dividing the arch ring so as to make $\delta s/I$ constant recommended by Prof. Turneaure is as follows:

In Fig. 11 lay off a base line AD $=s$ and divide this into eight or 10 equal parts numbered 1, 2, 3, etc. At the center of each erect an ordinate equal to the value of i for the corresponding point of the arch and through the points obtained draw the curve BC. From the values of i computed obtain the average value i_a and draw the line EF with i_a as the ordinate. Then by construction $ABCD=AEFD$.

The area $ABCD$ is now to be divided into n equal areas. Letting δs represent in general the base width of such subdivisional area and i its mean ordinate, each area is $i\,\delta s$ and the total area $ABCD=AEFD=n\,i\,\delta s$ $=s\,i_a$, from which

$$i\,\delta s = \frac{s i_a}{n} \quad (26a)$$

The value of the area $i\,\delta s$ can now be obtained and beginning at A or D the several equal areas can be readily laid off in succession, the values of i being scaled or interpolated.

Where the arch is symmetrical the values of $\delta s/I$ need be made constant for one-half the arch only, while if it is unsymmetrical the entire ring must be subdivided.

3. Loads—The amount and point of application of the various loads on the arch are next to be considered. For an open spandrel arch the live load and the dead load of the spandrel construction are applied at the points at which the spandrel arch piers or columns rest on the arch ring, while the dead load of the arch ring itself is applied continuously over the entire length. For purposes of computation where the spans of the spandrel construction are relatively short, this latter load can be considered as concentrated at the same points as the superstructure loads. Where the distance between spandrel piers or transverse rows of columns is over 10′ the arch ring should be divided into sections of from 5′ to 8′ in length and the weights of these sections considered as applied at their centers of gravity, thus giving two sets of loads to consider in the computations.

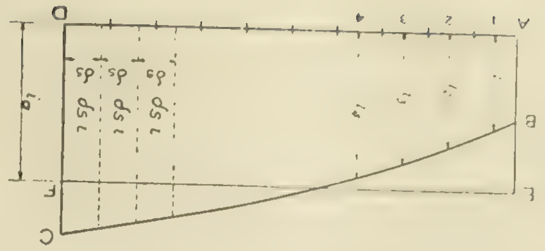


FIG. 11—GRAPHICAL SUBDIVISION OF ARCH AXIS TO MAKE $\frac{\delta s}{I}$ CONSTANT

In this connection it is well to note that the load divisions are in no way related to the divisions made to keep $\delta s/I$ constant and therefore need not coincide with them, but sometimes, for the sake of convenience, especially with earth-filled spandrel arches, the load may be subdivided so as to correspond with the arch divisions for stress calculations, and considered as applied at the center points. The main requirement of the load divisions is that they be small enough to make the errors of approximation involved, negligible.

4. Reduced Load Contour for Earth-Filled Spandrel Arches—In the analysis of an earth-filled spandrel arch the work is simplified by determining the reduced load contours for the different conditions of loading to be investigated. By reduced load contour is meant the line passed through points found by erecting ordinates at the ends of the load divisions expressing the depth of load in terms of equivalent concrete. Thus 1′ of earth fill would be plotted as $\frac{120}{150} = .8'$ of concrete and 200 lbs. per sq. ft. live load as $\frac{200}{150}$ or 1.33′ of concrete. By adding the thickness of the arch ring and the depth of fill taken as equivalent concrete, at any point, the ordinates for the reduced dead load contour are obtained and by adding to these the ordinates for live load as equivalent concrete the reduced live and dead load contour is obtained.

The load is in general divided into 10 or more equal divisions for each half of the arch and ordinates for the reduced load contour erected at the end of each section. For obtaining these ordinates the tabular form is the most convenient way of recording.

The values of column 4 in the table are not included in the totals, since these are automatically added when plotting the ordinates by starting from the extradosal line. Thus by plotting the values in column 6 of Table 1, starting with the extrados as a base the reduced dead load contour is obtained and by using those in column 8 in a similar manner the reduced live and dead load contour is found. For any condition of live loading desired the reduced load contour can be drawn by taking the proper values from the table.

With the aid of the reduced load contour the loads for each section are now computed, and here also the tabular form is the best for the computations.

TABLE II

LOADS FOR VARIOUS SECTIONS

Point	Dead Load Ordinate	Average Ordinate	Dead Load-Lbs.	Live Load-Lbs.	Total D. L. + L. L.
1	5.2′				
		5.35′	4,010	4,500	8,510
2	5.5′				
		5.7′	4,270	4,500	8,770
3	5.9′				
Etc.					

The values of dead load in Table II are found by multiplying the average ordinate of the section by the length of the division (assumed 5′ for illustration) and then by 150, the weight of concrete per cu. ft. The live load is obtained direct by multiplying the live load per sq. ft. (900 lbs. in this case) by the length of the load division.

Having found the amount of the loads the points of application must

TABLE I

ORDINATES FOR REDUCED LOAD CONTOURS

1	2	3	4	5	6	7	8
Point	Earth		Concrete	Ties & Ballast		Live Load	
	Depth	Equiv. Conc.	Depth Arch Ring	Equiv. Conc.	Total Cols. 3 & 5	Equiv. Conc.	Total Cols. 6 & 7
1	2.5′	2.0′	2.5′	.7′	2.7′	6.0′	8.7′
2	2.6′	2.1′	2.7′	.7′	2.8′	6.0′	8.8′
3	2.95′	2.4′	2.8′	.7′	3.1′	6.0′	9.1′
Etc.							

Assuming concrete to weigh 150 lbs. per cu. ft.; earth, 120 lbs.; ballast and ties, 100 lbs. per sq. ft., and live load, 900 lbs. per sq. ft.

next be determined. The load for each division is considered as applied at its center of gravity and with the reduced load contour drawn can most readily be found by the use of graphics as shown in Fig. 12.

The center of gravity of a trapezoid is found as follows:

Draw the diagonals *ac* and *bd*; divide either, as *ac* in half and then from *b* on *bd* lay off $bn = ds$ or from *d* lay off $dn = bs$; join *m* and *n* and locate the center of gravity at a distance equal to ⅓ *mn* from *m*.

If the load divisions of arch ring are taken at right angles to the arch axis, as is usually the case, the center of gravity of this portion will have to be found separately from that of the load represented by the area of a division between vertical lines above the arch ring. The common center of gravity can then be found by taking moments about one or the other of the centers.

5. *Co-ordinates of Loads and Arch Divisions*—The *x* (horizontal) co-ordinates of the various loads should now be scaled from the drawing and tabulated, as should the *x* co-ordinates of the centers of the divisions of the arch ring having a constant $\delta s/I$, both sets of co-ordinates being referred to the vertical line passing through the crown. The *y* vertical) co-ordinates of these latter divisions, referred to a horizontal line passing through the arch axis of the crown, should also be tabulated.

6. *Thrust, Shear and Moment at the Crown*—As the next step in the analysis the thrust shear and moment at the crown of the arch must be found and the theoretical considerations will accordingly be treated first.

To find the crown thrust H_0, the crown shear V_0 and the crown moment M_0, the arch if symmetrical is considered as cut at the crown (Fig. 13) each half acting as a cantilever subjected to the same forces existing in the arch. The bending moment at any one of the arch division centers due to the external loads will be negative. For M_R denoting moments in the right half and m_L in the left half at corresponding points having equal abscissas *x*. The values of H_0, V_0 and M_0 can now be found by the formulas

$$H_0 = \frac{n\Sigma my - \Sigma m\Sigma y}{2[(\Sigma y)^2 - n\Sigma y^2]} \quad (27)$$

$$V_0 = \frac{\Sigma(m_R - m_L)x}{2\Sigma x^2} \quad (28)$$

$$M_0 = -\frac{\Sigma m + 2H_0\Sigma y}{2n} \quad (29)$$

In which the summations of co-ordinates Σy, etc., are for one-half the arch and the summation Σm for the entire arch or $\Sigma m_R + \Sigma m_L$.

These values being determined, the total bending moment at any section is given by the formula

$$M = m + M_0 + H_0 y \pm V_0 x \quad (30)$$

the sign for the last term being *plus* for the left half and *minus* for the right. The resultant *R* acting at any section of the arch, can be found graphically or algebraically, since it is equal to the resultant of the loads between the crown and the section, and H_0 and V_0. The thrust *N* at any section can then be found graphically by resolving the resultant pressure *R* or by the formula 9, Part I. The thrust being found and also the eccentricity, the stresses in the section are computed by some of the formulas 11 to 24, depending upon eccentricity and character of the section.

$$Max.\ f = \frac{117{,}000}{2.8 \times 12 \times 12}\left\{1 + \frac{6 \times 0.3 \times 12}{2.8 \times 12}\right\} = 475 \text{ lbs. per sq. in.}$$

$$Min.\ f = \frac{117{,}000}{2.8 \times 12 \times 12}\left\{1 - \frac{6 \times 0.3 \times 12}{2.8 \times 12}\right\} = 105 \text{ lbs. per sq. in.}$$

The computations necessary to obtain the various quantities involved in equations 27, 28 and 29 are most advantageously performed by tabulating. Thus for live load on the left half of arch the table for moments *m* would be arranged as in Tables III and IV.

The values of H_0, V_0 and M_0 can now be computed from the values in Table IV.

$$H_0 = \frac{10(-59{,}772{,}478 - (-7{,}841{,}550 \times 32.95)}{2[(32.95)^2 - 10 \times 250.26]} = +116{,}000 \text{ lbs.}$$

$$V_0 = \frac{50{,}833{,}050}{2 \times 6{,}951.04} = +3{,}650 \text{ lbs.}$$

$$M_0 = -\frac{-7{,}841{,}550 + 2 \times 116{,}000 \times 32.95}{2 \times 10} = +9{,}857 \text{ ft.-lbs.}$$

A table of bending moments, eccentric distances and thrusts at the various points can now be made.

In Table IV the results are further tabulated for simplifying the substitution in the formulas for H_0, V_0 and M_0 by obtaining the values Σy^2, Σm, Σy, Σx^2, $\Sigma\ (m_R - M_L)\ x$, and Σmy.

With values of bending moments, thrusts and eccentric distances found, the stresses at the various sections can be obtained by the use of some one of the formulas 11 to 15. If the compression in the concrete is over 500 lbs. per sq. in. (for 1:2:4 concrete) some reinforcement should be used and the stresses recomputed by formulas 16 to 24, using the proper one for the case in hand. For ordinary dead and live load stresses no tension should be allowed in the arch ring.

The stresses at point 3 are found from equations 12a, Part I.

These indicate that no reinforcement is required, since no tension exists and the maximum compressive stress is within the allowable; however, when temperature stresses are added to these reinforcement will no doubt be required.

7. *Graphical Method of Determining m at Any Section*—For vertical loads acting on the arch the values of bending moments *m* at any section can be found graphically more readily than by the algebraic method just illustrated. The latter, however, is more flexible, since it can be readily used with loads acting in any direction. The graphical method is illustrated by Fig. 14. The various loads acting are plotted as the load line *acb* and a preliminary force polygon drawn with any selected point as *O* on a horizontal line from *c* at the center of the crown load as the pole. The equilibrium polygon *efg* is then drawn and a horizontal line *hi* drawn through the intersection of the line of action of the crown load pro-

TABLE III (PARTIAL)

MOMENTS m_R AND m_L

Point	Dist. from Crown	Load at Point	Sum of Loads	Dist. betw. Loads	Live Load on Left Half Increment of m_L	m_L	Dead Load only on Right Side Sum of	Increment of m_R	m_R
		Lbs.			Ft.-Lbs.	Ft.-Lbs.	Loads	Ft.-Lbs.	Ft.-Lbs.
1	1.8′	0	0			0	0		0
				0.90′	0			0	
Load 1	2.7′	6,240	6,240			0	4,140		0
				2.70′	16,600			11,180	
2	5.4′		6,240			16,600	4,140		11,180
				2.60′	16,000			10,775	
Load 2	8.0′	6,510	12,750			32,600	8,550		21,955
				1.05′	13,380			8,970	
3	9.05′		12,750			45,980	8,550		30,925

TABLE IV (PARTIAL)

VALUES OF $(m_R+m_L)\,y = my$ AND $(m_R-m_L)\,x$

Point	x	y	x^2	y^2	m_L	m_R	$(m_R+m_L)\,y$	$(m_R-m_L)\,x$
1	1.8′	0	3.24	0	0	0	0	0
2	5.4′	0.1′	29.16	.01	—16,600	—11,180	—2,778	+29,250
3	9.05′	0.35′	81.90	.12	—45,980	—30,925	—26,900	+135,300
4	13.05′	0.7′	170.30	.49	—96,980	—65,125	—113,300	+416,000
	Intermediate values omitted							
10	48.25′	11.9′	2,328.06	141.61	—1,648,980	—1,189,650	—33,800,000	+22,145,000
Σ		32.95′	6,951.04	250.26	—4,602,600	—3,238,950	—59,772,478	+50,833,050
					—7,841,550			

longed and the equilibrium polygon. The moments at the various points are then equal to the intercepts *z* from the equilibrium polygon to the line *hi*, multiplied by *H*, the pole distance.

The values of the crown thrust, shear and moment are then found as before with the aid of similar tables. The true pole of the force polygon is then found by laying off, to scale, V_0 vertically from the point *c* and from this new point H_0 is laid off horizontally, the true pole being at O_1. The force polygon is then revised and a new equilibrium polygon drawn in the arch ring working both ways from the crown. The point of application of the equilibrium polygon at the crown is found by dividing M_0 by H_0, the value obtained being the distance of the point of application above or below the crown. If the result is negative it is below the axis and above if positive. The thrusts at various points are given by the corresponding rays of the force polygon and can be scaled and tabulated as can the eccentric distances between the arch axis and the equilibrium polygon. These are tabulated and the bending moments found by multiplying the thrust by its eccentricity. With these quantities given the stresses in any section can be computed as before.

8. *Temperature Stresses*—In the preceding discussion on the computation of stresses in arches due to loads no mention was made of stresses caused by variations in temperature. These in most cases are of such magnitude that their consideration in the design is an absolute necessity. Tests made by the Engineering Experiment Station of Iowa State College indicate that the bending moments caused by variations in temperature are greatly in excess of those formerly believed to exist. The resulting moments for light highway bridges were found to be more nearly 100% than 10% or 20% of the dead and the live load moments as ordinarily allowed by some engineers in the design of arches. This gives an indication of the importance of investigating an arch for stresses due to temperature variations.

A variation of temperature in an arch causes a variation in its length and a deflection at any given point is the result. If the ends of the arch are free to move horizontally and the whole rib is free to rise or fall no stresses will exist in the arch due to temperature changes. In an arch with fixed ends any expansion of the rib due to a rise of temperature causes a horizontal thrust against the abutments and the rib tends to distort. For a drop in temperature the rib also tends to distort but in an opposite direction and the horizontal thrust is decreased. The distorting action due to a rise of temperature is resisted by the loads on the arch and additional stresses are thereby developed which must be added to the live and the dead load stresses. A drop in temperature below that assumed as standard for the design (based on the average temperature anticipated during construction) will tend to reduce the stresses due to live and to dead loads.

The maximum stresses due to temperature variations in general occur at the crown and at the ends of the arch. A temperature increase tends to produce tension in the extrados and compression in the intrados at the crown and the reverse action at the springing; a decrease in temperature has the opposite effect.

The bending moments at or near the springing as determined by the formula given later will be found quite large. Actually, however, the moments are not so high as the computations would show, since there is a yielding of the abutments at least, within the elastic limit of the materials composing them, which decreases the temperature stresses.

If the arch were unrestrained the increase in length of span for a rise of temperature of *t* degrees would be equal to *clt;* where *c* denotes the coefficient of expansion usually taken as .000006 and *l* the span. The restraint of the abutments produces a thrust at the crown which is given by the formula:

$$H_0 = \frac{EI}{ds} \times \frac{ctln}{2[n\Sigma y^2 - (\Sigma y)^2]} \quad (31)$$

This formula being based on the change in length for one-half span.

Having found H_0, the moment at the crown M_0 is given by the equation:

$$M_0 = -\frac{H_0 \Sigma y}{n} \quad (32)$$

The bending moment at any other point such as *D* in Fig. *15* is

$$M = M_0 + H_0 y \quad (33)$$

The shear at the crown $V_0 = O$. The thrust and the shear at any point can be found by resolving H_0 parallel and normal to the arch axis at that point.

In general a temperature of 50° F. is considered the standard for design (although this should be based somewhat upon the average temperature likely to be met with during construction) and a range of from

TABLE V

BENDING MOMENTS, THRUSTS AND ECCENTRIC DISTANCES

Point	m_L	m_R	M_O	$H_O y$	$V_O x$	Bending Moments Ft. Lbs. Left	Right	Thrusts—Lbs. Left	Right	Eccentric Distances Left Ft.	Right Ft.
1	0	0		0	6,570	+16,430	+3,310	116,000	116,000	+.14′	+.03′
2	—16,600	—11,180	+9,857 lbs.	11,600	19,700	+24,560	—9,420	116,300	116,600	+.21′	—.08′
3	—45,980	—30,925		40,600	30,200	+34,680	—10,665	117,000	117,000	+.30′	—.09′
4	—96,980	—65,125		81,200	47,600	+41,680	—21,665	118,000	118,000	+.35′	—.18′
	Intermediate values omitted										
10	—1,648,980	—1,189,650		1,391,000	176,000	—72,122	+35,210	147,000	138,200	—.49′	+.25′

Table VI

TEMPERATURE STRESSES

Point	y	H_0y	Bending Moment Ft.-Lbs. ±	Normal Thrust Lbs. ±	Eccentricity	Concrete Stresses—Lbs. Per Sq. In.			
						Temp. Increase	Temp. Decrease Extrados	Intrados Extrados	Intrados

20° to 45° above and below this is considered in computing temperature stresses. The lower value of $t=+$ or $-20°$ is used for earth-filled spandrel arches and the larger $t=+$ or $-45°$ is for open spandrel arches with severe exposure. The modulus of elasticity of concrete is taken as 2,000,000 lbs. per sq. in. or 288,000,000 lbs. per sq. ft. The dimensions in the preceding formulas should be in the same units, usually in feet.

If the line 00, Fig. 15, is at a distance d below the crown equal to $\frac{\Sigma y}{n}$, then the moments at its points of intersection with the arch ring are zero. Below the line they are all positive with the maximum, M, at the abutments, and above the line they are all negative. Such a line is the equilibrium polygon for temperature stress considerations.

To illustrate, if the thrust and the bending moment at the crown due to a rise of temperature of 20° desired, for an arch of 100-ft. span, with a value of $\frac{\delta s}{I}=2.25$, $n=10$ divisions $\Sigma y^2=250.26$, and $\Sigma y=32.95$:

$$H_0=\frac{288,000,000}{2.26}\times\frac{.000006\times30\times100\times10}{2(10\times250.26-(32.95)^2)}=5,430\ \text{lbs.}$$

$$M_0=-5,430\times\frac{32.95}{10}=-17,892\ \text{ft.-lbs.}$$

The equilibrium polygon is a straight line drawn at a distance below the crown equal to $\frac{17,892}{5,430}\doteq3.3'$.

Then the moment at any point can be obtained by multiplying H_0 by the vertical distance from such point to the equilibrium polygon. Thus at the springing line (arch having a rise of 14′):

$M=5,430\times(14-3.3)=58,100$ ft.-lbs.

The bending moment at any point can also be found by equation from which the moment at the springing line,

$M=-17,892+(5,430\times14)=$ 58,100 ft.-lbs.

For purposes of computation a table with the following headings in Table VI will be found useful:

The values of y are taken from one of the previous tables, the bending moment as indicated; the normal thrust by graphically resolving the thrust H_0 at the point in question, the component parallel to the axis being the thrust and the normal component the shear. The eccentricity is found as before and the unit stresses by formulas previously given (11 to 24, inclusive, as the case requires).

9. Stresses Due to Shortening of Arch Ring—The thrust produces compressive stresses in an arch ring and tends to cause a shortening of the span or the same effect as a decrease in temperature. If unrestrained the thrust producing an average compressive stress in the concrete throughout the arch ring equal to f_c lbs. per sq. in. would shorten the span by an amount equal to f_cl/E. The abutments of a fixed arch are assumed as unyielding, so that horizontal thrusts are developed at the crown by arch ring shortening.

By substituting f_cl/E for ctl in formula 31,

$$H_0=-\frac{I}{ds}\times\frac{f_c l n}{2[n\Sigma y^2-(\Sigma y)^2]} \qquad (34)$$

Using this value of H_0 the moments at the crown and at any point can be found by formulas 32 and 33, respectively. The thrusts and moments due to arch shortening are in general small except for very flat arches and can be applied as corrections to the thrusts and moments due to loads. For large and important structures, however, the stresses at the various sections should be computed with the aid of a table much the same as the one used for computing temperature stresses.

10. Maximum and Minimum Stresses—The stresses due to dead load and various conditions of live load, temperature variation and rib-shortening having been computed, they should be tabulated and such combinations of stresses made (as will occur at the same time) for extrados and intrados as will give the maximum and the minimum values. This table, which is really a summary of results of the various computations, shows at a glance the variation in stresses and the critical sections. As previously stated, if any of the stresses exceed the allowable the arch ring should be changed in shape to remedy the condition and a new set of computations made.

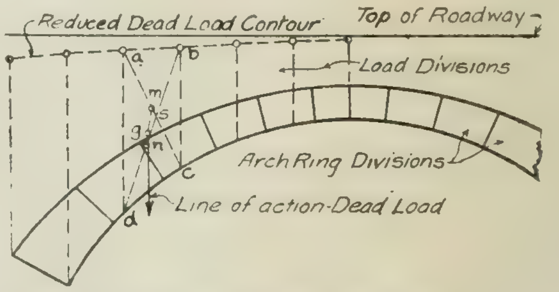


Fig. 12—Reduced Load Contour

Prof. Wm. Cain has demonstrated that for the analysis of arches under uniform loads the following conditions of loading will give the maximum stresses at the points generally requiring the most careful investigation: The maximum conditions of stress will occur at the left abutment section (skewback) and at the haunch section about ¼ span from the left end, with the load extending from the left end a distance of 0.4 of the span. For maximum stress at a section about ⅓ the span length from the right end the live load should extend 0.55 span from the left end and 0.65 span to give the maximum stress at the right springing line. For maximum stress at the crown the live load should extend 0.125 span on both sides of crown, but this condition is rarely considered since the stresses are not vertical.

The analysis for maximum stresses

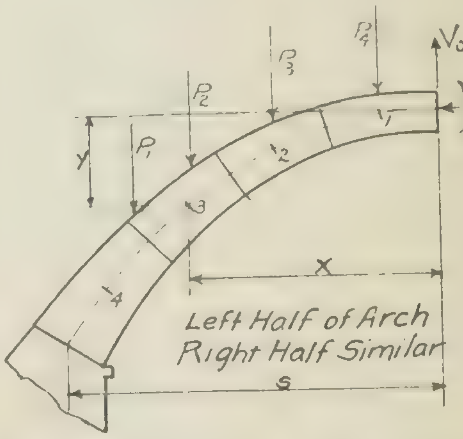


Fig. 13—Symmetrical Arch Treated as Two Cantilevers

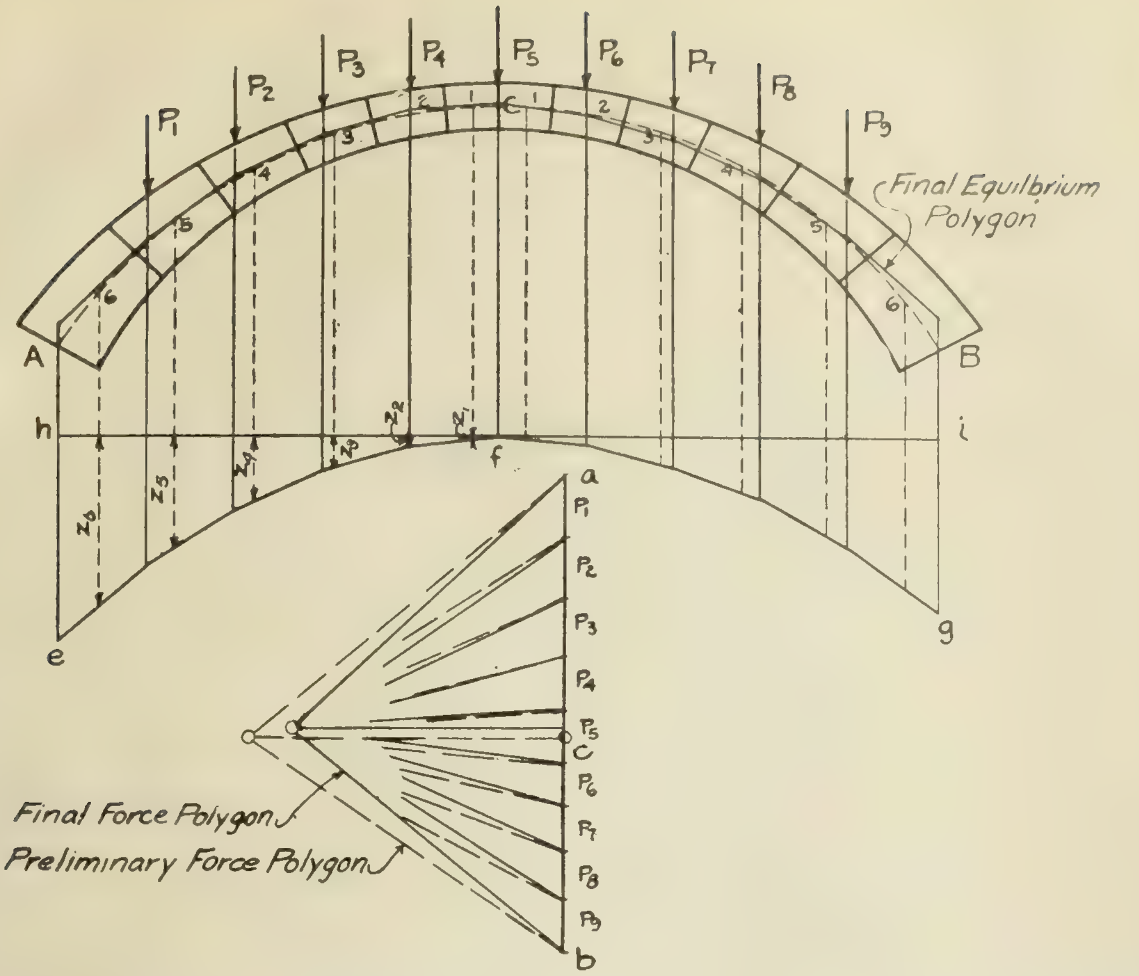


FIG. 14—GRAPHICAL METHOD OF DETERMINING CANTILEVER MOMENT "*m*" AT ANY POINT

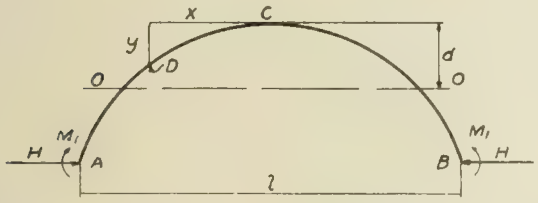


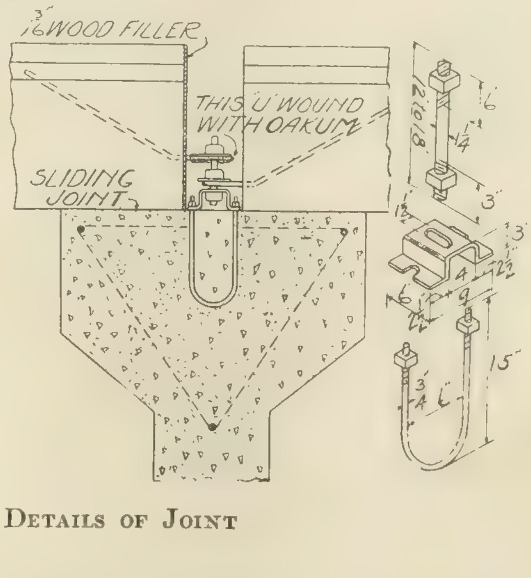
FIG. 15—MOMENTS AND THRUSTS DUE TO TEMPERATURE CHANGES

in all sections is greatly facilitated by the use of influence lines. In arches of ordinary span such detailed analysis is unnecessary, since if the maximum stresses at the critical sections are within the allowable the stresses at other sections will also be; however, in the design of large arches under moving concentrated loads the method of influence lines is the most convenient. Space does not permit the exposition of this method here and the reader is referred to the excellent treatment thereof in Turneaure and Maurer's *Principles of Reinforced Concrete Construction.*

The cheapness of fireproof building materials when compared with the value of the finished structure is the best argument for their wider use in the future typical building specifications. This argumentative asset has never been employed with anything like the insistence that it deserves. There has been entirely too much timidity on the part of the people who have the best goods to sell in not recommending them as broadly as they are well justified in doing. —*Rock Products.*

Holding-Down Device For Concrete Slabs

In the construction of what is locally known as the "High Dam" on the Mississippi river between St. Paul and Minneapolis an interesting device was worked out by the engineer in charge.[1] The dam, which is of the Ambursen type, was constructed as a reinforced concrete skeleton frame work to be covered on the up-stream side by pre-cast reinforced concrete slabs. This construction necessitated a joint which should not only be water-tight but which would remain tight under variations of temperature of nearly 140°. The illustration shows the general arrangement of framework, slabs, joint and holding device. The joints between the slabs were grouted after being assembled. At the right is shown a detail of the holding device which has been patented by the inventor and donated for government use.



DETAILS OF JOINT

While the general design of the device is apparent some considerations which prompted the exact details selected may be of interest. The U-bolt was adopted because it was easily and cheaply made, easily placed in the forms and readily held in exact position. It will be noticed that the girders on which the slabs were laid are so steep as to require cover forms when being poured and the necessity for a device which could easily be accommodated to the forms is apparent. The clip with the oval bolt hole as shown allows a slight adjustment which is necessary in handling such large units under field conditions.

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[1] Maj. Geo. W. Freeman, Asst. U. S. Engr., St. Paul

The Use of Concrete in Sea-Water

According to William Hood, present practice on the Southern Pacific railroad in depositing concrete under sea-water is about as follows. After selecting the best available cement, it is mixed rather dry and the concrete is deposited as much as possible where there is no current or movement of the water. A long cylindrical bucket with a butterfly-leaf bottom is used to deposit the concrete. The bucket is lowered into position closed and is hoisted away from the concrete so that the latter does not fall or drop through the water.

Cement that contains a large proportion of aluminum does not behave well under sea-water, but this tendency seems to be largely counteracted when a considerable amount of iron oxide is present. As a general rule, if the proportion of iron oxide is subtracted from the proportion of aluminum, the difference should not materially exceed 4%. For instance, if the proportion of aluminum is 7.11%, and the proportion of iron oxide, 3.34%, and the cement is otherwise satisfactory, it may be used under sea-water. Or if the proportion of aluminum is 6.71% and that of iron oxide, 2.09%, and the cement is otherwise of particularly good quality, it can still be used under sea-water.

It is also advisable to keep a careful watch upon the cement during the first few days after being mixed, and if it develops extreme slowness of setting or other objectionable qualities, to discontinue the use of that particular brand.—*Western Engineering.*

The Manufacture and Sale of Concrete Burial Vaults

(Staff Article)

There is an increasing recognition of the lasting qualities of burial vaults made of concrete. While the manufacture of such vaults is being undertaken in many places by men who specialize in this work only, there is good reason to believe that in most communities the work could be handled more economically and probably be better done in a concrete products plant doing a general line of work. Undoubtedly, one thing that has prevented the more rapid development of this line for concrete products manufacturers is the feeling of uncertainty as to the sales problems envolved. Some of the successes in this work, however, indicate that the sales problems are by no means so serious as some might believe and the problems which do exist have at least the advantage of being very direct and not scattered among the general public. Practically all business is done direct with undertakers.

Practically all of the work in making a concrete burial vault can be done by one man with the assistance of one other man at odd times and for only a few minutes at a time. It is possible but not usual for one man to make one vault per da. The few operations in manufacture which usually require that two men be on the job is one of the things which should be considered by concrete products manufacturers generally in giving them an advantage over the man who is in the vault business and not making other products. In large centers of population, where the use of the concrete burial vault may be expected to increase rapidly, the work in time undoubtedly would require several men to handle it. At least one company in this country is manufacturing concrete burial vaults as an important side line and finds it worth while to have one executive in charge of the business who spends practically all of his time in an extensive sales campaign. In smaller communities this would not be so big a task and a few undertakers in any community would be practically the only ones to be convinced of the value of the product at the price at which it can be sold.

An excellent quality of product can be made at such a low cost that it is possible to give the undertaker a very large profit in selling the vaults and still have the total price to the buyer lower than any other vault with which the concrete vault has to compete.

Providing the manufacturer is careful in his workmanship and gives a good product, there is usually very little difficulty in convincing the undertaker of the value of the product and of its lasting qualities.

On the care necessary in manufacture there can scarcely be too much emphasis. This will be obvious to most concrete products manufacturers. Because the concrete vault has such thin walls and these walls are divided by metal reinforcing fabric, there must be a very carefully prepared concrete mixture and this must be placed with a great deal of care in order not to have cavities and pinholes. We are indebted to the manufacturer[1] of a system of molds for making concrete burial vaults for some how-to-do-it information on the actual processes of making vaults.

SETTING UP MOLDS

The space required for the work is small. Most manufacturers will begin with three sets or four sets of molds and as the product will remain in the molds for about 4 das. the space necessary will be that required for setting up and getting around that many molds. The molds used in the particular system described here are handled upside down, with the bottom of the vault upward. The metal covered platform which appears as the bottom for the side walls of the vault and which supports the entire work during casting should be supported by blocks on six concrete piers, perfectly level. The tops of these piers should be level with the floor. Of course if there is a perfectly level concrete floor these piers are not necessary, as the platform is actually supported by wooden posts set on the tops of these piers. The way the parts of the mold are put together and the reinforcing fabric put in place are conditions which vary with the system of molds used. The timbers resting on the piers or on the concrete floor to support the platform or bed of the mold should be about 6″x6″ and 16″ long. There should be one at each corner and one in the center of each long side. The metal surface of the mold bottom should be carefully greased with crude oil which has been thinned with coal oil. The inside or core of the mold is first set up and this is also greased. When the core is all set in place the expanded metal is fitted around it. There must be care taken to cut and place it so that the thin mixture of cement and sand will flow all around it. Spacing wires should be placed throughout the fabric at intervals to hold it away from the core and away from the outer wall of the mold. The side and end plates and corners, forming the outside of the mold, should be carefully greased on the inner surfaces before they are set up.

MATERIALS AND MIXING

Cement and clean, well graded sand in a proportion of $1:1\frac{1}{3}$ or $1:1\frac{1}{2}$, with about 2% of good integral waterproofing compound, are ordinarily used. Manufacturers who are not producing other concrete products probably will not require a mixer for the small amount of material which they use. In fact most manufacturers of burial vaults who are not in other lines of work do not use a mixer. The mixing box should be about 3′ wide by 8′ long by 12″ deep. By flaring the ends of the box it is easier to keep it clean and to keep the mixture from splashing. The ingredients of the mix should be thoroughly mixed dry before any water is added. It is exceedingly important that a good clean sand be used—one which is well graded—and the mixing should be very thoroughly done. The walls of the vault are so thin that the least imperfection practically means failure. Water should be added to the materials slowly while one man continues to mix. Mixing should continue until there is a mixture which will readily flow into the small space into which it must be placed. It is important that the mixing continue longer than for any ordinary work because the mixture has to be used so wet that unless it is thoroughly mixed there will be a separation of the sand, the cement and the water when it is poured. It is well recognized, for instance, in the manufacture of concrete stone by the wet process that unless it is possible to take the mixture direct from the mixer it is practically essential that some sort of agitator be used to continue the mixing, in order to have the mixture homogeneous at the moment it is placed in the mold. It will be perfectly clear that this precaution might well be taken in making burial vaults. It is always difficult to describe just how wet a mixture should be. In this case it should be no wetter than is absolutely necessary to place it properly in the molds. Experience has shown that the development of small pin-holes in the vaults tends to indicate that the mixture was too thin, that is, that it had too much water in it. Large cavities which did not fill up indicate that the mixture was too thick, that it did not have enough water. When the mixture is wet enough, both men should mix and when it has reached the proper consistency one man should do the pouring while the other man continues to mix what remains of the batch in the box. This necessity for most thorough mixing would almost seem to indicate that the manufacturers would do better to have a mixer for the purpose, even when their output is very small.

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[1] Norwalk Vault Co., Norwalk, Ohio

In pouring the molds full, the pouring should be done mostly at the corners. When the concrete has been filled into the mold to the level of the core, it should be carefully spaded into place by using a strip of band iron about 1″ wide and about 1/3″ to 1/4″ thick. This should be thrust down inside the mold next to the outside and the inside plates and worked along the sides of the molds until the operator is certain that the mixture has been allowed to flow into every bit of space there is. When this work has been done thoroughly, the rest of the mold is filled up to the top of the outer part of the mold, over the core, thus forming the bottom of the vault. When the mixture has set for a time some water will come to the surface. This is easily removed by rolling a piece of 1½-in. gas pipe over the surface back and forth, thus pushing the water ahead of it. Ordinarily in about 1 hr. (although the time will vary somewhat with the curing conditions) the bottom should be straight-edged and carefully finished with a trowel. It is best to round the corners slightly, as this avoids chipping in handling the mold later on. The vault should be left in the mold for about 72 hrs. This time, however, will vary with curing conditions. Unless steam curing is used it probably is not wise to remove the vault from the mold in much less time than 72 hrs. Most manufacturers of burial vaults are not using steam curing. In such thin work, however, it would seem good practice to do so and there should be some economy in it by requiring fewer molds.

The cover of the vault, in a separate piece, is made by a different method. A drier mixture is used than in the vault when it has to be placed over a curved and inclined surface and finished in that position. The same proportions of materials as for the vault proper, should be thoroughly mixed, dry, as for the vault itself, then a portion of this dry mixture should be mixed separately to about the consistency recommended for sidewalk top coat work. This mixture is placed around the vertical edges of the cover mold up to the point where a drier mixture has to be used on the curved surface. The thin bands of reinforcing fabric used in the edges of the lids are forced down into the mixture after it is placed. The remainder of the dry mixed material should be mixed up as for ordinary so-called dry-tamp work, getting just as much water in, however, as is possible and still have the material stand up. The quantity of water will be much higher than in block work because of the larger proportion of cement in the mix. All of the concrete in the cover should of course be tamped into place. A straightedge the full length of the cover should be used to obtain the true surface on top. After the concrete has been placed and allowed to set for a time the surface should be given a regular sidewalk finish. The finishing should be done most carefully. On removing the sides of the lid mold it is best to go over the edges with a file and round them off slightly and take off the roughness.

The concrete vault is too heavy to lift in the ordinary way, so when the time comes for the removal of the mold from the vault it is common to use a turning device and a truck to handle the vault with the mold on. This turning device consists of two X frames like the ends of a saw-buck with an arrangement on the mold and on the frames for pivoting the mold so that it can be turned over as though on an axle. When these frames are in place the wood blocks are knocked out along one side under the platform, another frame first having been clamped on top of the work, or on what is the bottom of the vault, holding it firmly as a new platform on which it will rest when it has been turned over. The clamps extend down and grip the platform on which the vault was cast. The entire work is then turned over and a low truck run underneath to support the vault on the frame which has just been clamped on. The mold is then loosened and removed. The molds are carefully cleaned and oiled and it is best not to do any finishing on the vault until the following day. When the vault is to be finished up it is still resting on the frame on the truck or possibly on the floor, having been removed from the truck. Mix up a thin wash of pure cement and paint this on over the surface with a whitewash brush, going over only a small area at one time and rubbing over carefully with excelsior. When this is finished the vault is ready to be lifted and put away on shelves for further curing. A triplex hoist or ordinary block and tackle will have to be used to swing these vaults, in placing them on the shelves. The date of manufacture should be marked on each vault and they should not be used until at least 30 das. after manufacture.

The vault maker is usually notified by an undertaker at least a full half-day or possibly a day ahead of the need for the placing of the vault in the grave and in this time the vault is to be taken down and carefully painted with a special waterproof paint. The paint should never be applied when the vault is first removed from the mold because the vault should have time to cure thoroughly and to become perfectly dry after curing.

Under almost all conditions it is up to the manufacturer of the vault to place it in the grave. He has to make the delivery, send a man along with a tripod and block and tackle and lower it into place. This is usually done an hour or so before the funeral. When the vault is first placed the edges where the seal is to be made should be carefully gone over with a preparation which will clean the surface and insure a good bond. There should be no paint on the edges nor on any of the sealing surfaces. These should be washed with clean water a half hour later. After the casket is placed the lid is put on, care being taken to center it properly within the projecting flange of the vault itself and leaving an equal space all around for the sealing mixture.

The price of burial vaults to undertakers is usually $25 or $30. This includes placing the vault. The price which the undertaker charges is all the way from $50 up to $75, so that he makes a big profit and becomes a good sales influence for the manufacturer.

Slab Design to Use Less Concrete Is Verified by Experiments

By Robert B. Melvin[1]

In this article Mr. Melvin takes a stand in direct opposition to commonly accepted theories of floor design. He demonstrates both theoretically and through practical tests that all concrete in floor structures is in tension and none in compression. It is evident that the practical results of the general acceptance of these theories would be to increase floor spans and greatly reduce the amount of concrete considered necessary under present assumptions. This seems to be a matter of vital importance to the industry and discussions of the following article will be welcome.

It is the purpose of this discussion to refute the following accepted assumptions:

1. That when subject to bending, horizontal compression occurs at certain points in a concrete beam or slab with fixed ends.
2. That there is a neutral plane when in this condition of bending.
3. That in such a member under bending stress the maximum horizontal and the maximum vertical shear occur at the same point.
4. That in such a member under bending tension and compression can occur simultaneously between any two restrained points of a straight line or horizontal fiber.

These assumptions will be refuted by showing that when a concrete beam or slab with fixed ends is deflected there is neither a neutral plane nor compression in the horizontal fibers. In other words, this discussion is to show that the effects of the action of stresses in a concrete beam or slab supported is entirely different from the effect of stress action in a concrete beam or slab with fixed ends—the difference to be shown by a comparison of the behavior of the two members under bending.

The practical effect of this new theory in the practice of concrete engineering is intended to be the reduction of the thickness of concrete slabs to the minimum point of practical construction, which is 4″ or 5″ of concrete, the same amount of reinforcing to be retained for a given span and load, and to increase the length of spans.

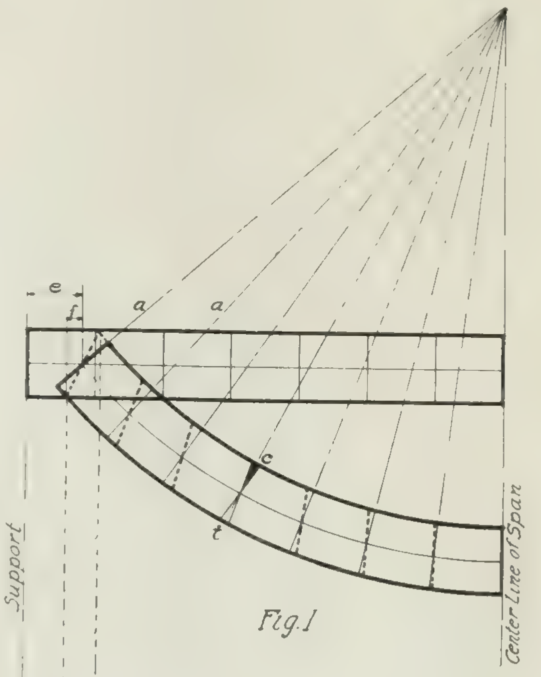

Fig. 1

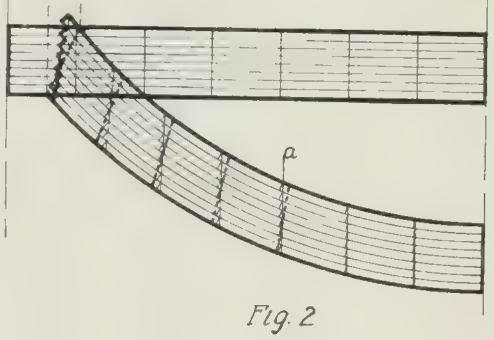

Fig. 2

PRINCIPLES OF SIMPLE BEAM ACTION

It is a well known fact in simple beam action that after bending the horizontal fibers above the neutral plane are shortened, those below are lengthened and that the fibers of the neutral plane are the same length before and after bending, as shown at Fig. 1, where the neutral plane is shown the same length after bending as before.

It is also true that after bending, the ends of the fibers of the neutral plane approach the center line of span in a horizontal line, or in other words, if the neutral axis at end of member is held in its original horizontal plane, it will slide horizontally toward center of span, as shown at (e) Fig. 1.

If the vertical planes, after bending, followed radial lines as in Fig. 1, there would be perfect resistance to horizontal shear, the particles composing the member would compress above and stretch below the neutral plane in accordance with the deflection curve as at (a) Fig. 1. Every horizontal fiber except the neutral plane would be a different length before and after bending and this stretching and shortening would represent, by its length, the effect of the tension and compression sustained by each horizontal fiber, as at (t) and (c) Fig. 1.

If, as in Fig. 2, the horizontal fibers would slide upon each other without shearing resistance, there would be neither tension, compression nor a neutral plane, all horizontal fibers would remain the same length and the distance between vertical planes, measured along the horizontal fibers, would be the same. The end of the center horizontal fiber, if held in its original position, would slide along its horizontal line and be nearer the center line of span after bending than before just as in the case of Fig. 1. And the vertical planes, after bending, would take the position shown at (a) Fig. 2.

Neither of these effects of bending occurs, however. The actual result is an average of the two, the particles above the neutral plane being pushed toward the supports and those below being pulled toward center of span horizontally, as a result of the natural resistance to shearing. The vertical particles of the horizontal fibers take an average position between those shown in Figs. 1 and 2, represented by the inclined dotted lines, which show the true position of the vertical planes of a simply supported member after bending.

It will be noted in Fig. 1 that the vertical plane cutting the center line of span always remains vertical, the horizontal planes remain horizontal and there is no tendency to shear horizontally at the center point of the span.

As the bearing end of the member is approached, the vertical planes become inclined, the horizontal shear increases, and is maximum at the bearing end or at the point of greatest vertical shear.

The ends of the horizontal fibers, below the neutral axis thrust out beyond the end of the neutral plane toward the support, due to the lengthening of the fibers below the neutral plane as shown at (f) Fig. 1.

It will also be noted in Fig. 1 that the end of the member has pulled *away* from the support at (e) a *much greater* distance than (f).

ACTION OF A CONTINUOUS MONOLITHIC STRUCTURE UNDER BENDING

Now let us consider the action of a continuous or fixed end monolithic structure under bending.

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[1] Constn. Supt., Cleveland

In Fig. 3, representing a member with fixed ends, the neutral plane is shown the same length after bending as before. As in the case of Fig. 1, it is assumed that tension, compression and perfect resistance to horizontal shear occur and the spaces (a) would be shorter after bending, than the corresponding spaces (b) before bending. It will be noted also that the end of the member at (d) does not reach the center line of span.

Fig. 4 shows this member deflected without horizontal shearing resistance, the same as in Fig. 2, except that the horizontal fibers are stretched until they reach the center line of the span at (d).

The conclusion is that there is no neutral plane with this condition of bending and that the distance between vertical planes at top and bottom of the beam, measured along the horizontal fibers, is greater after bending as at (d) than at before bending at at (b).

Since neither result of the assumed conditions of bending is possible, viz., bending with perfect resistance, or with no resistance to horizontal shear, as stated in connection with Figs. 1 and 2, it follows that the vertical planes must take an average inclination as shown by the dotted lines of Fig. 5 instead of the position shown in either Fig. 3 or Fig. 4, the same as shown in simple beam action.

Now compare Figs. 3 and 5. In Fig. 3 the distance (a) is *less* than (b), showing compression at (a). But the end at (d) does not reach the center line of span. It has pulled back. In Fig. 5, the distance (a) between the dotted lines showing the true position of vertical planes after bending is *greater* than (b), showing *tension* instead of compression at this point, *because the horizontal fibers are stretched until they reach the center line of span at (d).*

In other words, *every horizontal fiber throughout the vertical section of a fixed beam must stretch or pull apart when the member is deflected.*

Let us further illustrate the condition by cantilever action. The cantilever shown in Fig. 6 is a true cantilever with a neutral plane. Now assume that two such cantilevers are connected at the ends as in Fig. 7. *The stress in that portion of the horizontal fibers below the neutral plane is reversed—compression becomes tension.*

To make this more clear consider Fig. 6 composed of a number of wires placed one on top of the other in a vertical line. A load placed at the free end of the cantilever would cause the wires below the neutral plane to buckle in compression and to cause those above to stretch. Now suppose the ends of these wires were connected with the ends of another such cantilever and loaded at same point as shown in Fig. 7. *All the wires would be in tension.*

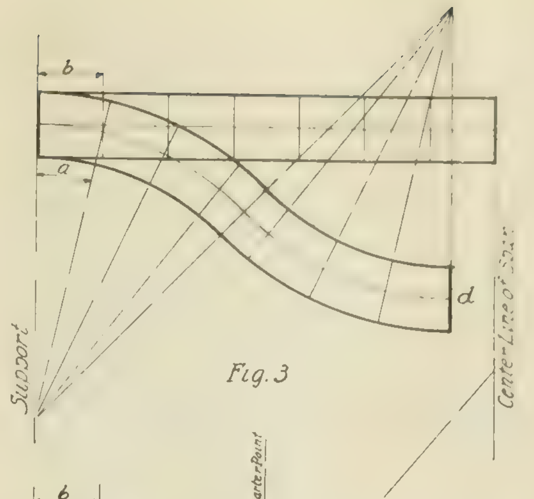

Fig. 3

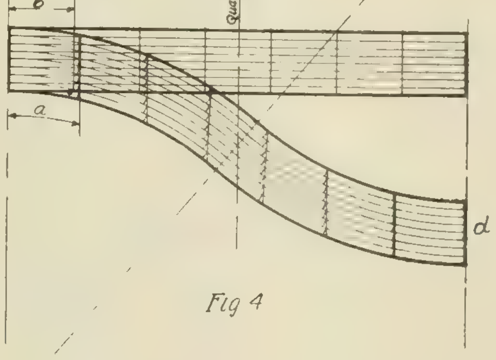

Fig 4

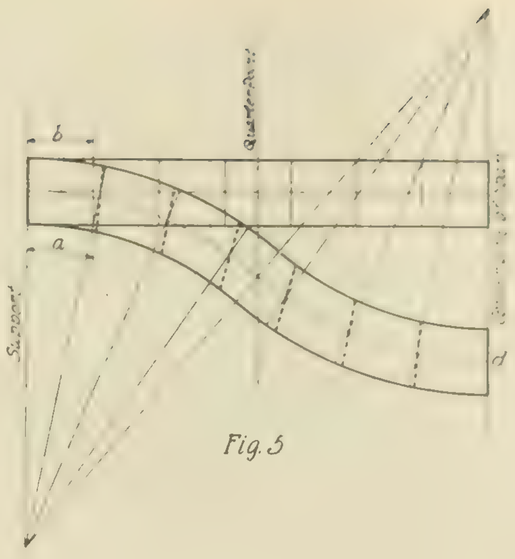

Fig. 5

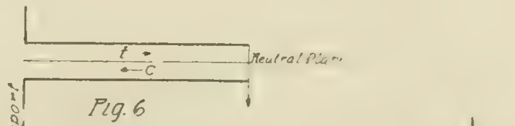

Fig. 6

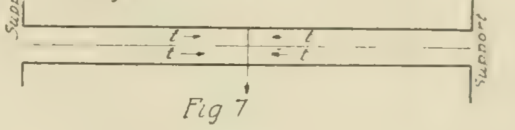

Fig 7

At the support and at the center line of span of Fig. 5, there is no tendency to shear horizontally, and the point of maximum horizontal shear in this case is at the quarter point, as will be seen by Fig. 4. *Maximum horizontal shear could not possibly occur at the support or point of maximum vertical shear with any system of loading, as is usually assumed.*

In considering these different conditions of bending it must be borne in mind:

1. That after bending the length of the neutral plane of a simply supported member does not change, the vertical plane at center line of span remains vertical and the point of greatest horizontal shear is at the support as in Figs. 1 and 2.
2. That the vertical planes at center line of span and at support of a member with fixed ends, remain vertical; the horizontal planes at these points remain horizontal; the point of greatest horizontal shear is between the support and center line of span and that the middle horizontal plane does stretch as in Figs. 4 and 5, owing to the fact that a curved line between two points must be longer than a straight line connecting the same two points.

If the assertion is made that the destructive forces do not travel in horizontal and vertical lines and the element of arch action is injected into the discussion, we enter an entirely different field which would have no value here. However, it has been sufficiently demonstrated that the value of arch action in a flat arch 6″ thick and say a 12-ft. span, is not worth considering.

THE TEST

The writer made the following practical test to find a steel ratio which would cause failure by crushing of the concrete in a reinforced slab with fixed ends. Results did not agree with the accepted assumptions used in the design of monolithic construction.

The slab tested was, as shown by the illustrations, 2″ deep, 6″ wide and 5′ clear span, and was loaded with a concentrated load of 1,800 lbs. at center of span. A 1:2:4 concrete, 1 mo. old, reinforced with 3 ¼-in. round rods, was used. While loaded, more than half of the concrete was cut from compression side of slab at supports and center of span, throwing an apparent compressive stress of about 7,000 lbs. per sq. in. into the remaining concrete section. There was not the slightest indication of crushing. Tension cracks, extending from bottom to top of slab, occurred at the quarter points at 1,000 lbs. concentrated load and did not incline toward center of span, as would be the case in a simply supported member, but toward supports.

The result of this test clearly indicates that the strength of continuous construction, with the reinforcing properly bonded, depends entirely upon tensile values; that it has no relation to simply supported conditions, and that monolithic structures designed according to the usual as-

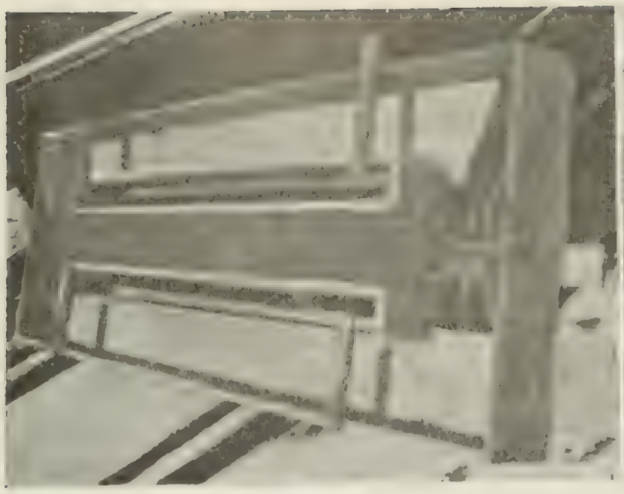

Fig. 8—Form and Reinforcing for Test Slab

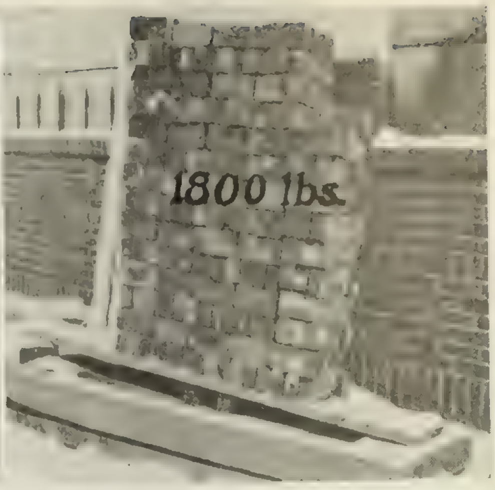

Fig. 9—Test Slab Showing Method of Loading

sumptions are supporting an unnecessary dead load of concrete.

The results of my investigation thus refute the accepted assumptions:

That there is horizontal compression at any point in a member with fixed ends. That there is a neutral plane in this condition of bending. That the maximum horizontal and maximum vertical shear occur at the same point. That tension and compression can occur simultaneously between any two restrained points of a straight line or horizontal fiber.

The practical application of the true condition, viz., that there is tensile stress only in monolithic construction, is to reduce the thickness of concrete slabs or beams to the minimum point of practical construction which is a 4-in. or 5-in. covering of concrete, retaining the same amount of steel for a given span and load.

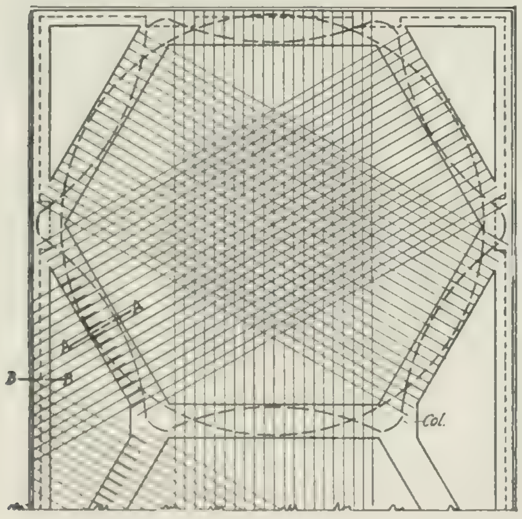

Fig. 10—Typical Floor Bay, 3-way System

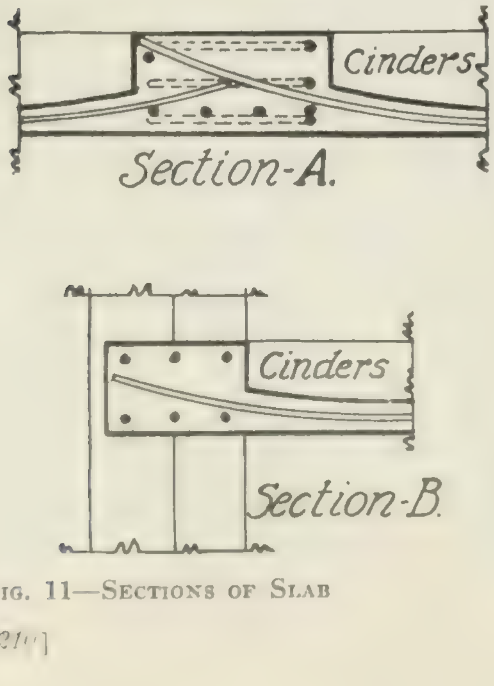

Fig. 11—Sections of Slab

Figs. 10 and 11 show a long span, concrete-protected, suspension steel floor, composed of steel rods or bars, encased in concrete and arranged in three-way system to act as flanged circular plates suspended between girders or trusses designed to resist bending horizontally. The suspension principle may be applied to the one- or two-way systems also.

Floors constructed on the suspension principle require less columns, giving more clear floor space.

The thickness of concrete covering the steel is reduced as compared with floors designed on the neutral plane assumptions and length of spans are limited only by practical considerations.

Concrete Hotel Proves Fireproof

A hot fire in the ball-room on the 11th floor of Hotel Radisson, Minneapolis, Oct. 9, at 3 a. m., destroyed the contents and decorations of the room, with a loss of about $40,000, yet most of the guests did not know of the fire and the normal operations of the hotel were not hampered. An announcement by the hotel management to its patrons said in part:

> Regrettable as this occurrence was, it is, however, not without its gratifying features. The fire developed a very intense heat, sufficient to cause the plaster to crumble and exposed iron to melt. The concrete walls and floor confined the fire to the room and prevented spreading. The firemen's hose played on the fire upwards of an hour, thereby throwing a large amount of water into the room, yet the floor below suffered no water damage whatever. Because of the fire and smoke-proof elevator shafts and entrance doors, no fire or smoke entered any of the floors below, or above the Silhouette floor.
>
> This catastrophe demonstrates the claim the Radisson has heretofore made, viz., that its building is as fireproof as modern methods and material can build. While it is possible that a fire may arise in any one room, yet because of the construction it is practically impossible for the fire to travel beyond the room.

Concrete "Breakers" to Prevent Washing of Maryland Roads

A novel but thoroughly practical device is used in Maryland to prevent the washing of road shoulders and gutters. According to H. G. Shirley, chf. engr. of the Maryland State Roads Commission, these "breakers," as they are termed, answer their purpose so well that they will pay for themselves after two or three heavy storms. They are considerably cheaper than cobble-stone gutters, give thorough protection to the shoulders of the road and may be used on any type of highway, including farm lanes and driveways.

Briefly described, the breaker consists of a low concrete barrier extending from the edge of the road diagonally through the shoulder to the ditch. It is built flush with the surface of the road shoulder, and where highways are patrolled and shoulders kept in repair, it is no obstruction to travel. Breakers are spaced as occasion may require, and are neither expensive nor difficult to build. The Maryland breakers are 12″ wide and 18″ deep. As stated, spacing varies with the nature of the soil, grade, and the amount of water they encounter. Thus it would probably be necessary to space them closer at the bottom of a hill than at the top. On 5% to 6% grades and medium soil the breakers are spaced 25′ to 30′ apart. Where the soil is liable to wash and the grade steeper, they would be spaced much closer. The length as well as the grade of a hill would also influence the spacing.

Local materials are usually used to build the concrete breakers. This makes the cost very low, and as the requisite materials are found in practically every section of the country, breakers could be used with economy on all types of highways, even including the common dirt road. A great deal of repair work of costly nature is occasioned by torrential rains, resulting in serious washouts, and judging from the success obtained by the use of the breakers in Maryland they would be an economical investment in all parts of the country.

Use of Bulk Cement in Concrete Products Plants[1]

By D. W. King[2]

If the manufacturer of cement bags had been confined to European countries and no substitutes were available during the present crisis many of the concrete products men would be surprised to find how well they could manage to do without the cement package. By bulk cement I mean cement which is shipped from the mill to the consumer in box cars and without its being bagged in the customary cloth or paper sacks. It is the purpose of this paper to show the reasons for the increasing use of bulk cement and to give a few suggestions applicable to concrete products manufacture.

In the last three years the cement company which I represent has shipped approximately 250,000 bbls. in bulk and this cement is known to practically every class of consumer who receives cement in carload lots. Six railroad companies have used bulk cement in their construction work with satisfactory results and large contractors such as the Thompson-Starrett Co., Westinghouse-Church Kerr Co., The Mueller Construction Co., of Chicago; Pike and Cook; The Haglin Stahr Co., and the Nelson-Enblom Company, of Minneapolis, are bulk cement users. Corporations such as Standard Oil Co., Illinois Steel Co., National Tube Co., and the American Sheet & Tin Plate Co., are consistent users of bulk cement.

The work of loading bulk cement at the mill is exceedingly simple. When the cement is shipped in sacks the loading of an average car requires that 800 sacks be filled, each having the proper quantity of cement weighed into it, after which these sacks must be conveyed into the car and piled. When a car is to be loaded with bulk cement it is fitted with grain doors and a spout is set in place through one of the car doors. The cement is measured by means of a device called a weightometer.[3] This device weighs the cement as it passes along the belt conveyor, which carries it to the spout already mentioned. Adjacent to the loading platform is a dial, on which is recorded the cement as it passes bbl. by bbl. over the conveyor. Beside the dial is a switch controlling the movement of the conveyor. It is only necessary, therefore, to throw the switch in order to start loading the car and wait until the dial records the loading of the proper number of bbls. of cement. Then the switch is thrown off and the loading is completed. Careful tests have shown that the weightometer is extremely accurate, much more so in fact than any other cement measuring device that we know of.

Bulk cement is much surer to get to its destination in good shape than sack cement. The jolting of the car in transit causes it to settle down so that when the car reaches its destination the surface of the cement is smooth and level, while the material is so compacted that a man can walk over it without sinking into it above the soles of his shoes. In the entire history of our bulk cement shipment we have never had a claim for loss or damage of bulk cement while in transit. Several cases have been noted where bulk cement cars with leaky roofs have passed through rain storms, but in these cases the damage was so slight as to be negligible. Underneath the hole in the roof would be formed a small lump of cement about the shape and size of a soup plate. When this was thrown out the rest of the cement was ready for immediate use. When a car of sack cement is exposed to similar treatment the rain does not stop on the surface of the load, but flows down through the spaces between the sacks and passes out upon the car floor, partially damaging every sack of cement with which it comes in contact. Nails which work out of the car floor or siding are one of the most prolific causes of trouble with sack cement. It is impossible to prevent these nails from being worked out by the straining of the timbers of the car when it is in motion.. These nails are the cause of many sacks being torn, with a consequent loss of cement and additional labor in handling the torn packages. Nails have no such effect on bulk cement.

Experience has shown that the unloading of bulk cement raises less dust than sack cement. This may seem incredible, but when the porous nature of the cloth cement sack is considered it can readily be understood that more dust will be raised by dropping the sacks of cement upon a truck than by allowing a shovelful of closely compacted cement to slide into a wheelbarrow. There are two well established methods of unloading bulk cement. First by means of shovels and wheelbarrows and second by means of a power scoop, such as is used for unloading grain. It is possible to unload a large car of bulk cement in less than 2 hrs. by means of the power shovel.

A great many people consider that one of the objections to the use of bulk cement is the question of measuring it. These same people never experience any difficulty in measuring bulk sand and bulk stone. There is no reason why bulk cement should not be measured in wheelbarrows in exactly the same way as sand, gravel or stone. In the case of a 1:2:4 mix measured in this way any factor of error that may exist is likely to be constant in the case of all the materials, whereas if the cement is measured in sacks that factor of error will be multiplied by 2 in the case of the sand and by 4 in the case of the stone, thereby producing an under- or over-cemented concrete. If greater refinements of measurement are desired measuring boxes of different types may be used, or if exact measurements are wanted the materials may be measured by weight.

The shipment of cement in bulk results in a measure of economy to the cement manufacturer. The expense of operating a sack department is considerably reduced. The partial elimination of bagging material reduces the investment in cement sacks, in bagging machinery and other equipment. It also reduces overhead expense, involving the auditing of sack accounts and the maintenance of a sack department which takes care of cement package from the time of the manufacture of the raw cotton into fabric, the manufacture of the bags themselves and records their movement from the time they are put into use until they are finally worn out and rejected. A reduction in the time of loading and the simplification of operating methods are also important advantages from the manufacturer's standpoint. From this it is evident that the cement manufacturer effects a saving which is proportionate to the amount of cement he is able to ship in bulk form. It is therefore reasonable to suppose that the price of cement in bulk may be lowered below the net prices of cement in cloth or paper packages. At the present time the company which I represent makes a reduction of two cents a bbl. in the net price of bulk cement.

The cost of the cement package to the consumer is high. It is customary nowadays to add 10 cts. to the net price of a bbl. of cement for paper bags and 40 cts. for cloth sacks. For the paper bags the customer pays a flat charge of 10 cts. per bbl., and to this should be added the increased labor cost, due to the extra care necessary to avoid breakage, for the paper bag is rather a fragile container for such a heavy commodity as cement and is much more liable to damage in transit, growing weaker with repeated handling. The returnable cloth sack when properly handled is a more economical package than the paper bag, but it is far from being a free package. It is the general experience of cement manufacturers that from 10% to 15% of the cloth sacks that they ship out are never returned. Assuming that 10% are lost or destroyed we get a charge of 4 cts. per bbl. for the foundation of our bill of expense against the cloth sack. To this should be added the cost of taking care of, counting, bundling and shipping the sacks back to the mill. If the work is properly done a cost of $2.50 per thousand sacks (or .9 of a cent per bbl. of cement) is far from being unreasonable. Therefore it is fair to say that cloth sacks cost cement users about 5 cts. per bbl., without figuring interest on money tied up in sacks both filled and empty, and other items of expense that might justly be added.

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[1] Paper delivered before American Concrete Pipe Association, Feb., 1915.

[2] Universal Portland Cement Co., Chicago

The average carload of cement contains about 200 bbls. or 800 sacks. Therefore, the invoice for a carload of these sacks in cloth contains a charge of $80 for packages. The sacks are to be paid for with the cement and no credit is allowed for them until they have been returned to the cement manufacturer and subjected to his count and inspection. A considerable number of sacks both filled and empty must accumulate on every job and for every 10 sacks that accumulate a dollar of capital is tied up.

It is possible to save a considerable amount of labor by installing a cement bin in the products factory from which the cement runs by gravity into a measuring box and then into the hopper of the mixer. Such a bin may be filled by means of a bucket elevator or any other efficient system which will elevate the cement from the car to the bin. When such equipment is installed it is necessary to expend but very little labor in handling bulk cement from the time the cement is received until it is used in the mix. With sack cement considerable labor is required in storing the cement in the first place and afterwards using it in the mixer, sack by sack. This requires that the sacks be brought from the cement storage room to the mixer and piled in a convenient position for use. The sack must be untied, lifted over the mixer hopper, emptied, shaken and laid aside, after which it is necessary to sort, count, bundle and ship the sacks back to the mill. The method of handling bulk cement after it reaches the factory varies a great deal according to local conditions, but when special equipment is installed the principle of operation is about the same in all cases. The bucket elevator may be located close to the track so that the cement may be shoveled by hand or by means of a power scoop into the bottom of the elevator leg. It is then elevated and drops into an overhead bin, which should be conveniently located to the mixing plant. If it is impossible to have the bin in close proximity to the mixing plant, it is often found practicable to convey the cement to the mixer or measuring box by means of a spiral or a belt conveyor. Unit storage bins are now furnished on the market at reasonable cost; a 50-yd. bin consisting of four 12-in. x 12-in. posts, paneled sides and hopper bottom may be bought for $450, or in pairs for about $600. An elevator suitable for elevating 100 bbls. of cement per hr. can be bought for about $275. A power scoop similar to that used in unloading grain from cars, but made somewhat heavier and to operate at a slower speed, will cost about $100. Thus the equipment necessary for storing 675 bbls. of cement or about 3 cars should not exceed $1,000 and the power for operating is almost a negligible factor.

It is not absolutely necessary to install special equipment in order to handle bulk cement in the products factory. In this case the cement may be wheeled from the car to the storage bin and stored in much the same way as sacked cement. Then if it is used rapidly one man will generally be able to keep the mixer supplied. If only a part of one man's time is available for supplying the mixer with cement, a box may be provided near the mixer to be filled at convenient intervals from which cement may be dipped by a bucket or other means. It is, of course, advantageous to have the cement bin located close to the mixer to reduce labor in handling. One products plant in central Illinois stores the bulk cement upon the second floor of its factory. A hopper shaped box having a spout reaching to the mixer on the ground floor is filled from time to time. It is only necessary to fill this box twice a day by shoveling from the pile a few feet away to keep the mixer supplied. The cement is conveyed to storage from the car by wheeling it in wheelbarrows up an inclined runway about 75′ long. This is a good arrangement for a plant where the track level is somewhat higher than the ground floor of the plant and where no special equipment is desired.

Another plant in northern Illinois which uses bulk cement has a bin in one corner of the mixing room nearest the track. The car is spotted opposite the door and the cement nearest the opening is shoveled and thrown into the bin. As the unloading progresses, it is more economical to load it into wheelbarrows and wheel them over a runway into the shed to dump them. This does not cost any more than it does to unload sack cement, as with the latter it would be necessary to lift the sacks from the wheelbarrow or truck one by one and pile them, while with bulk cement the operation of dumping takes but a second.

A plant in the central part of this state using bulk cement in concrete tile manufacture has an elevated track through the building in which it carries on its work. An elevated bin holding 1½ cars of cement is filled by a bucket elevator which is installed close to the track. The cement is shoveled into the bottom of the elevator leg and drops into the bin above. A spiral conveyor at the bottom serves to convey the cement to the mixer, which happens to be one of the continuous variety. When it is desired to fill the cement hopper of the mixer a clutch is thrown in and a few turns of the spiral conveyor are all that is necessary. This products manufacturer has not only been able to save the labor of one man since installing this equipment, but is buying his cement 2 cts. per bbl. cheaper and saving 1 ct. per bbl. in eleminating the handling of sacks, to say nothing of a former loss of from 1 ct. to 4 cts. per bbl. in lost and damaged sacks. His equipment cost as follows:

Concrete footings (labor and material)	$ 10.00
Lumber for bin	122.31
Labor building	94.25
Bucket elevator (installed)	167.86
Total	$394.42

I recall the case of a concrete silo stave concern in Indiana, which closed contracts for over 130 silos before its plant was ready to operate. It began using bulk cement at a rapid rate and wheeled it direct from the car to the loading skip of the mixer. This proved so successful that storage of cement was generally unnecessary except occasionally a fraction of a car was stored to facilitate unloading other material. The plant operators were able to save in this way from 5 cts. to 8 cts. per bbl. in first cost, labor and elimination of package expense. When cement is being consumed in this way at the rate of 50 bbls. per day, bulk cement may be used at a saving. The railroads allow two das. for unloading a car, so that the maximum demurrage on a car detained 4 das. would be $2.00. When cement is being used at this rate the consumer will undoubtedly take it from the car whether it be in sacks or in bulk, but in the latter case a saving of $8 to $10 per car may generally be effected, even though 4 das. have been consumed in unloading it.

Information and Consultation: The How-to-Do-It Department □ □ □

This magazine is for service. Let it serve you, and you help it to serve. You want special information. Ask us. We know the men who know.

Concrete Floors in Foundries □

THE QUESTION BELOW IS DISCUSSED BY:

WILLIAM M. KINNEY[1]
CARL H. FULLER[2]

"What special precaution should be taken in the construction of a concrete floor in an iron foundry where molten metal is likely to come in contact with it? How should such a floor be built?"

BY MR. KINNEY

We assume that the only time molten metal is likely to come in contact with the floor is when a small amount is spilled on it occasionally, and a concrete floor of dense, hard concrete should not be injured. Such a floor as this should be laid in a single course, using a 1:2:3 mixture, and aggregates that are hard, tough, durable and not affected by high temperatures. When finished the floor should be covered with wet sand or sawdust and *kept wet* for 10 das., in order that it may cure properly.

BY MR. FULLER

Aside from any consideration of the destructive effect of hot metal coming in contact with concrete floors in foundries, the heavy weights continually being handled over them or dropped upon them would necessitate better and heavier construction than is used for ordinary purposes, but such increased thickness or better quality in the concrete alone will not meet all the requqirements as the contact of hot metal or hot castings piled on the floor will produce local temperature stresses to which no monolithic floor slab can be subjected with impunity.

The destructive effect of these local and unequal temperature strains may be minimized by laying the floor in blocks 3′ x 3′ or 4′ x 4′ and having a well defined sand joint between adjacent squares. In addition, the floor should be reinforced in both directions by 3/8-in. or 1/2-in. deformed bars, spaced not more than 1′ apart or a combination of bars and wire fabric, extending through from block to block.

There is no question about the disintegrating effect of excessive heat or that the handling of heavy materials over the floor all tend to loosen, break and separate the surface from the base, when the top dressing is applied in the usual manner. There are two ways to minimize this trouble.

Mix and place the base in the forms quite wet, leaving the surface as rough as possible and applying the top dressing *immediately.* The topping should be dry enough to absorb some moisture from the base below. The difficulty with this method is to impress upon the mechanics the need of applying the top dressing before the base has had a chance to acquire any initial set, the object being to avoid any possible line of cleavage between the base and the top dressing. It is doubtful that this line can be absolutely prevented.

The second method eliminates any possibility of cleavage, by omitting the topping entirely. Add to the base material, when mixed, the sand and cement that would have been used for the top dressing, making the concrete just that much richer in fine stuff. A 1:2:3 mixture is about what is required, as too much stone makes the work too difficult. Mix quite wet and place in the forms so that there will be a slight surplus. Float with a long wooden float, of sufficient length to reach from form to form, pressing below the surface all the stones that appear during the operation. Then when it sets up sufficiently, finish with a steel trowel, doing the least work possible to get a good surface. This method requires a little more skill on the part of the mechanic but any intelligent workman can quickly acquire the knack.

Either method means that the floor layer must work strictly according to specification, but the slight extra cost will be fully justifiable. It is impossible to prevent absolutely the cracking of individual slabs, but if there is a well defined sand joint between the blocks, the crack will not extend into the adjacent block and when a slab becomes too badly broken it may be taken out and a new one replaced with the minimum of labor.

The writer learned this latter trick while in the employ of a large steel plant that used concrete floors around its bessemer and open-hearth furnaces. Large quantities of hot metal and slag were frequently spilled on these floors and very heavy weights were continually handled over them, a service no floor could withstand for any great length of time. Yet the results obtained there would indicate that the same construction in a foundry, with its less severe conditions, would last a long time.

Pemeta, Okla., is talking of a new use for concrete road. It is proposed to establish a park and through it to build a winding roadway 12′ to 16′ wide, to be used for roller-skating. This new type of rink is to be lighted at one side.

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[1] Engr., Infor. Bur., Universal Portland Cement Co., Chicago

[2] Engr., Greensburg, Pa.

Uses of Ground Slate

THE QUESTION BELOW IS DISCUSSED BY:
LEONARD C. WASON[1]
SANFORD E. THOMPSON[2]
WILLIAM M. KINNEY[3]
THE EDITORS

"I should like information as to the possibility of using slate refuse as an aggregate in making concrete products, and any other information as to other uses which might be made of this raw material."

BY MR. WASON

We have never used this material and therefore cannot speak from personal experience. By the use of the word "ground" we understand that you mean finely pulverized. This has been presented to us by dealers as a coloring for granolithic sidewalks, but as its color is too near that of cement we have not used it, because using a sufficient amount to get the proper color was an adulterant which we did not feel justified in putting into cement. If the material is of coarser nature, like a sand or a coarse aggregate, and if it is not in too flat slabs, it may be used for concrete as other stone or sand aggregates are.

BY MR. THOMPSON

There is serious objection to slate refuse as an aggregate for concrete products. As coarse aggregate, the lamination affects its adaptability for such purposes, and also it is a stone which is low in strength and therefore tends to give a concrete of low strength. In crushing for use in fine aggregate, the hardness is of less importance, except that screenings naturally contain a large percentage of dust, which is detrimental to their use.

BY MR. KINNEY

By the term ground slate we assume that you refer to the material obtained after the refuse is put through a crusher. The use of this material in the manufacture of concrete products has not come to our attention heretofore and since the possibilities would depend to such a large extent upon the character of the slate and the condition of the particles after crushing, we believe that the best way to determine its usefulness would be to make thorough physical tests of the crushed material and compression tests of concrete made with various mixtures; the slate being a laminated material, could possibly come in the same class as shells from oysters and clams, which, we understand, have been used in concrete work on the Gulf Coast with fair success, but its possibilities would necessarily need to be determined by tests.

EDITORIAL DISCUSSION

Crushed slate was used with apparent satisfaction by Schaefer Bros., Rochester, N. Y., in the manufacture of a special stone required in the erection of an addition to a public building where the architects specified that the manufactured stone should match in appearance as nearly as possible the very dark natural stone in the original building. Trap work did not prove dark enough and it was not thought advisable to use lamp black in sufficient quantity in the facing to give the desired depth of color. A black slate was obtained and crushed in the factory of Schaefer Bros. Coloring matter was then used in the cement in a limited quantity but the manufactured stone depended chiefly for its appearance upon a well graded mixture of the crushed black state. The surface of this stone was afterwards tool-dressed to expose the dark aggregate.

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[1] Aberthaw Constn. Co., Boston

[2] Consult. Engr., Newton Highlands, Mass.

[3] Engr., Infor. Bur., Universal Portland Cement Co., Chicago

Effect of Lubricating Oils on Machinery Foundations of Concrete

THE QUESTION BELOW IS DISCUSSED BY:
L. C. WASON[1]
WM. M. KINNEY[2]

"Have lubricating oils a disintegrating effect on concrete foundations of machinery? What precautions should be taken in building such foundations?"

BY MR. WASON

More than 15 years ago, when concrete in engine foundations was a relatively new material, there was some apprehension as to the effect of engine oil upon it. Our investigations at that time, which were somewhat extensive, led to the conclusion that engine oil has no chemical action upon well set concrete. Where a light foundation was built which was subject to vibration and became saturated, there were a few isolated cases, not positively proved, in which the lubrication assisted the vibration in impairing by mechanical means the solidity of the mass. We performed some experiments by casting neat cement briquettes and immersing them in oil at various ages, and found that those which were set in damp air for 3 das. or more were not injured by subsequent immersion in oil. Those which were immersed at a shorter period were somewhat impaired in strength.

BY MR. KINNEY

In our opinion the information available covering the effects of oils on concrete indicates that mineral oils, in which class lubricating and engine oils can be included, have little or no effect on dense, thoroughly cured concrete, the only action apparently being a tendency to soak somewhat into the concrete.

The only precaution needed where concrete is to be used for machinery foundations is to provide well proportioned concrete of a mixture that will give proper density and strength and to see that the concrete is protected during early hardening, so that it will have opportunity to gain requisite strength and cure thoroughly. Sometimes on large foundations a rich mortar facing is utilized which provides a smoother, denser surface than could be obtained by the leaner mixture of concrete forming the mass of the foundation.

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[1] Pres., Aberthaw Constn. Co., Boston

[2] Engr., Infor. Bur. Universal Portland Cement Co., Chicago

Coloring Concrete Roof Tile

THE QUESTION BELOW IS DISCUSSED BY:
JULIUS RUOFF[1]

"I am going to make some concrete roof tile of a wet mixture of 1 part cement and 2½ parts sand, the tile to be 2′ wide, 4′ long and

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[1] Ruoff Constn. Co., Philadelphia

1" thick, reinforced with wire fabric. What is the best way to color these tile on the exposed surfaces?"

By Mr. Ruoff

I would advise the use of ¼" of colored mortar on the surface, made of 1 part of colored cement and 1½ parts of sharp, crushed stone sand. The cement and color have to be mixed separately by a mixing machine or through a fine sieve so that a uniform color will result. By using waterproofing in the surface finish, the tile will be waterproof. A good weatherproof color ought to be used mixed with cement 4% to 6% of color (by weight of cement); it will give a bright, strong color.

Editorial Discussion

One manufacturer of concrete roofing tile sprinkles his color dry on the surface of the freshly molded tile after surplus moisture has been brought to the surface and then before removal of the tile from the machine, trowels the surface and thus works the color over and into the surface. There is some question of the lasting qualities of color applied in this way. Time and exposure will tell.

Do Septic Tank Outlets Freeze? □

The Question Below is Discussed By:

Wm. M. Kinney[1]
E. M. Santee, M. D.[2]
E. K. Borchard[3]

"We have noticed that nearly all descriptions of septic tanks specify that the outlet and the lines of tile leading from the outlet should be placed about 15" below the surface of the ground. Kindly advise as to the action of the overflow in the climate of New England, where the ground freezes to a depth of 4'."

By Mr. Kinney

It is generally considered that sufficient heat is developed by septic action to prevent trouble in this direction. A crust of ice will, of course, form on the ground surface but this seems to aid in retaining the heat of the sewage, so that with sandy soil, absorption continues practically uninterrupted. It is necessary, however, properly to adjust the size of the irrigation system to the actual area needed, as interruption to bacterial action causes loss of heat. Ogden and Cleveland in their *Practical Methods of Sewage Disposal*, after describing the conditions under which sub-surface irrigation is most effective, state: "The temperature of the sewage will prevent its freezing even in very severe winter weather, especially when the ground is covered with snow."

By Dr. Santee

Tile in disposal area of septic tank do not freeze in a 12-in. ditch where the thermometer goes down to 40° below 0. This seems incredible but is literally true. I can give dozens of names, from my files, of people who have had them for years in places colder than New England.

By Mr. Borchard

We have no record of complaints due to the effluent freezing, even in the coldest weather.

In connection with the subject of the effluent discharge from septic tanks, we believe that if a tank is situated in a locality where the winters are severe there should be installed a dosing chamber provided with an automatic siphon. The function of the siphon and the dosing chamber is to discharge the effluent periodically and in considerable quantity.

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[1] Engr., Universal Portland Cement Co., Chicago

[2] Sanitary expert, Cortland, N. Y.

[3] Inform. Bur. Assn. Am. Portland Cement Mfrs., Philadelphia

Protection of Concrete Platforms □ □ □

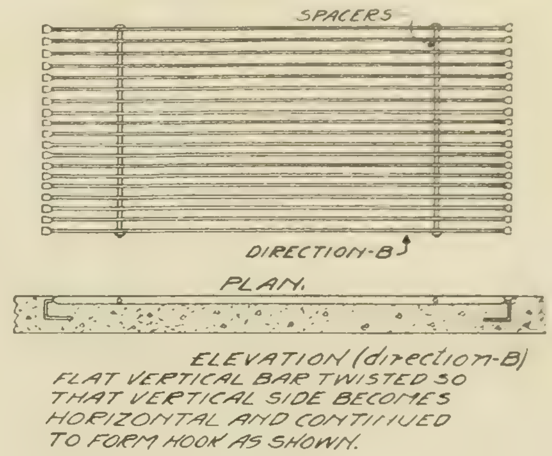
The Question Below is Discussed By:

H. C. Campbell[1]
D. Whiting & Sons[2]
I. S. Merrell[3]

"What is the best means of protecting concrete platforms where milk cans are handled? Iron plates have been mentioned, but it is suggested that difficulty would be found in securing a suitable bond between plate and concrete. Can you suggest proper protection?"

By Mr. Campbell

The accompanying sketch suggests a method whereby the loading platform may be protected by means of parallel iron bars, placed similar to a sidewalk grating, and embedded in the concrete. In the opinion of the writer, this would be the best solution of the problem.


SPACERS
DIRECTION-B
PLAN.
ELEVATION (direction-B)
FLAT VERTICAL BAR TWISTED SO THAT VERTICAL SIDE BECOMES HORIZONTAL AND CONTINUED TO FORM HOOK AS SHOWN.

These bars should be spaced 2½" apart, and should be held at a uniform distance from each other by being drilled near each end, as shown in the sketch, and possibly at the center, rods passed through the holes, these rods being threaded throughout their entire length, and nuts screwed on them so that they will act as spacers and locks to hold bars the fixed distance apart. Bars should be 2" wide, and every alternate one should be turned at the end by forging, so as to form a hook that may be embedded in the concrete, as shown in the sketch representing a sectional elevation. "Sleeves" should not be used on the rods as spacers, as they are likely to fit loosely and will not make so rigid a construction, nor result in so good a bond between concrete and metal.

From D. Whiting & Sons

Iron plates set in concrete or asphalt have been used by us with very good results where the floor is subjected to extreme wear from the rolling of cans and the passage of trucks. The iron plate used by us has been in the form of a gridiron about 1½" thick, with interstices about 1" wide. In other milk plants we know of the successful use of plates 12" to 16" square, perforated with holes about 1" in diam.

By Mr. Merrell

We do not know of any way to accomplish satisfactorily the result you are looking for. The weight and hammering of the cans will dislodge the metal and crack the concrete to such an extent that it becomes unsanitary. We do not believe it is advisable to try to set metal with concrete, but prefer to use the metal alone.

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[1] Chicago. Courtesy *Hoards Dairyman*

[2] Milk Dealers, Boston

[3] Vice-Pres., Merrell-Soule Co., Syracuse

Correspondence: A Department in Which the *Reader* Becomes the *Writer*

This is your department. It is informal. Use it. This is the place for letters which have either inspiration or information for the "other fellow." It is well to remember that you are usually in his position. If you are to get the good out of these columns, why not help to make them good? Write about your work. Help the Other "other fellow."

More About Hydrated Lime in Spouted Concrete

LETTERS FROM NORMAN G. HOUGH[1] AND W. H. INSLEY[2]

In the Nov., 1915, issue of CONCRETE a correspondent comments upon an editorial which appeared in the Sept., 1915, issue on the subject of chuting concrete and calls attention to the fact that the addition of hydrated lime to the mix prevents separation of the aggregate. The following letters emphasize the same facts.

BY MR. HOUGH

Your Sept., 1915, issue contained a very interesting article from J. H. Ames relative to the necessity for the replacement of more or less concrete bridge work due to various reasons.

Fig. 1 in that article shows a portion of concrete in which the use of too much water had caused the fine particles of the aggregate and the inert matter to settle in a layer.

Does not this bring out very strongly the advisability of incorporating in concrete some material which, through some physical property, would guard against the use of too much water and very largely diminish the possibility of the coarse aggregate separating from the cement and the sand? This question of separating would seem to be important as there are involved not only the question but subsequent results in the strength of the concrete. The most important factor connected with securing ultimate strength in concrete is the uniform distribution of the cement throughout the mass, provided, of course, that the amount of cement is consistent with the loads to be imposed.

One of the difficulties connected with placing concrete, especially when it is being deposited by means of chutes, is that oftentimes the concrete will not flow freely but sticks and clogs in the chute. In an effort to overcome this condition, it is the most natural thing to add water. One trouble is corrected, but another, and a more serious one develops—that of separation of the aggregates.

The use of small percentages of hydrated lime, (from 5% to 15% depending upon the proportion and gradation of the aggregates) has been found to be valuable for guarding against the use of too much water and consequently reducing to a minimum the possibility of segregation.

It is a well known fact that when hydrated lime is added to a cement mortar the mortar is made to work much more freely, and it has been demonstrated in actual field construction that increased plasticity is given to concrete upon the addition of small amounts of hydrate, to such an extent that the aggregates flow freely and smoothly through the chutes and are deposited in the forms with the cement more uniformly distributed throughout the mass than is the case when the use of too much water has caused the mortar to separate from the coarse aggregate. The use of hydrated lime would therefore seem to be justifiable even if its advantages stopped at this point, which, however, is not the case.

BY MR. INSLEY

I note the statement in your publication with reference to the subject of spouting concrete that "an objection to its use is the tendency, in order to secure an easy flow, to use too much water, causing a dangerous separation of the concrete—the flow of concrete depends not only on its fluidity, secured by an excess of water but also on its plasticity, which is also an entirely different property."

There is a mistaken notion held by a great many people that the flow of concrete can be improved by an excess of water. Too much water is as great a hindrance to the flow of concrete in a gravity chute as is too little water. There is a mixture which is just exactly right and which can be readily obtained by a very little observation and experience, this mixture holding all of the aggregates in suspension. One can tell when he has the right mixture by taking one of the large aggregates, say a large piece of gravel or of stone and placing it in the top of the hoisting bucket after the batch has been dumped from the mixer. If this gravel is held above the top of the concrete so that any part of it is not immersed, the mixture is too dry. On the other hand if the gravel sinks into the concrete 3″ or 4″ the mixture is too wet. The gravel should ride just under the surface of the concrete as it stands in the hoisting bucket, that is, it should be easily and readily held in suspension by the mixture.

If the concrete has more water than is required to hold the larger aggregates in suspension, the tendency is for them to ride toward the bottom of the mass and to drag on the bottom of the chute and to retard the lower stratum of concrete as it flows down the chute, allowing the wetter upper stratum to reach the forms first. If the concrete is too dry, of course the whole mass tends to clog. There *is* a *right* mixture, which is the only right mixture, however, and with this mixture there is absolutely no difficulty about the flow of the concrete.

Timely Article Helps Subscriber

A LETTER FROM ERNEST A. LLOYD[1]

The accompanying illustration shows a concrete job I am doing near here using a skip as described in the Sept., 1915, issue of CONCRETE except that it is larger and heavier, being made ample size for a 1-sack batch. I consider it a great success. You will notice that the

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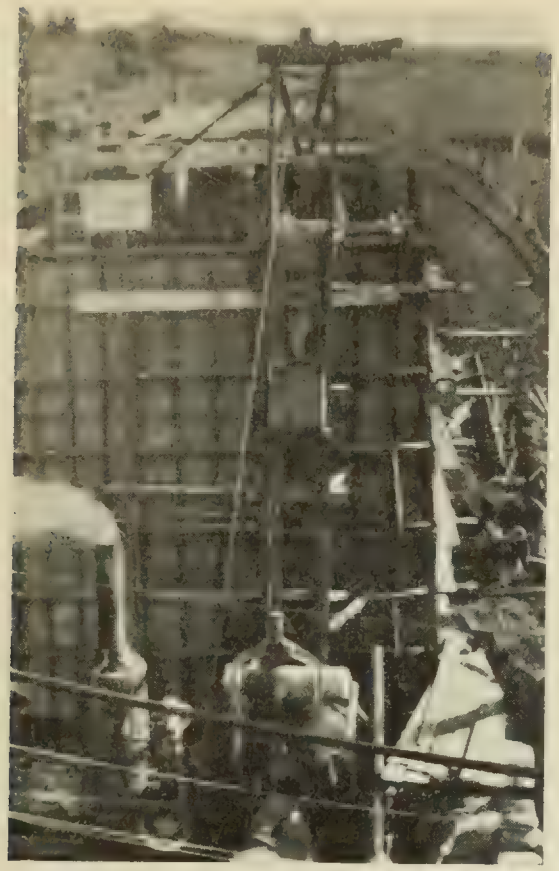
[1] Mgr., Hydrated Lime Bureau, Pittsburgh

[2] Pres., The Insley Mfg. Co., Indianapolis

[1] Contractor, Victoria, B. C.



Placing Concrete With Home-Made Skip

skip is operated by a belt off the fly-wheel of the engine. The mixer is a No. 6 Foote[1] 20-ft. capacity; the engine will hoist both loader and concrete skips at the same time on 125 lbs. of steam. CONCRETE is a great success.

Organizations

American Concrete Institute, Charles L. Fish, Secretary, Harrison Building, Philadelphia, Pa.

American Concrete Pipe Association, Secretary, E. S. Hanson, 538 S. Clark St., Chicago.

American Highway Association, Chas. P. Light, Field Secretary; Colorado Bldg., Washington, D. C.

American Road Builders' Association, Secretary, E. L. Powers, 150 Nassau St., N. Y. C.

Association of American Portland Cement Manufacturers, Percy H. Wilson, Secretary, Bellevue Court Building, Philadelphia, Pa.

Cement Products Exhibition Co., 208 S. LaSalle St., Chicago, Ill.; Robt. F. Hall, Secy., Chicago Cement Show, Coliseum and First Infantry Armory, Feb. 12-19, 1916.

Mid West Cement Users' Association, Secy.-Treas., Frank Whipperman, Omaha. Neb. Convention, Omaha, Mar. 1-4, and Mid-West Cement Show, Feb. 29-Mar. 4, 1916.

Second National Conference on Concrete Road Building, J. P. Beck, Sec'y, 208 So. LaSalle St., Chicago. Chicago, Feb. 15-18, 1916.

Am. Road Builders Convene in February

The Executive Committee of the Am. Road Builders' Assn. announces that a convention of the Association will be held in Pittsburgh, Feb. 22-25, 1916. While the Association participated with the Am. Highway Assn. in the Road Congress at the Panama Pacific Exposition, it is felt that if the Association waits until 1917 to hold another convention the lapse of time will be altogether too long; therefore it has been decided to hold a convention early in 1916 and probably continue to hold conventions at that season in the future instead of the late fall as heretofore. In connection with the Pittsburgh convention, it is announced that the City Council has appropriated funds to put Mechanical Hall of the Exposition Building in shape for the meeting. This will provide facilities not only for the convention but for the exhibitions of road building materials and equipment.

New Books

Plain and Reinforced Concrete Arches—By J. Melan, authorized translation by D. B. Steinman, cloth, 6" x 9¼", 162 pp., 43 figures, John Wiley & Sons, $2.00.

A complete and admirable translation of Prof. J. Melan's article on the subject of concrete arches as published in the *Handbuch für Eisenbetonbau* (Handbook of Reinforced Concrete Construction), which is recognized as one of the most thorough treatments of the subject ever written.

By the conversion of all numerical examples and data from metric to English units the value of the work so far as the American engineer is concerned, is greatly enhanced, for a book which speaks in terms not common in the particular place in question is never popular.

The fundamental principles of arches are treated in Chapter 1, and stresses in reinforced concrete sections in the next; these are the preliminary chapters of the work. The theory and methods of analysis for the three-hinged and the hingeless arch form two of the most important chapters in the book. Analytic and graphic methods of solution of the hingeless arch are given in considerable detail. Chapters 5 and 6 deal with the effects of temperature and displacement of abutments, and the action of non-vertical loads. A chapter on approximate methods of analysis for the hingeless arch follows. This portion of the work will be welcome as a check upon the more detailed and exact method. Two-hinged and one-hinged arches are briefly treated, followed by chapters on arches with elastic abutments and arches continuous over several spans which discuss phases of the subject generally avoided because of their intricacy. These chapters are worthy of considerable study and application, and are alone worth the price of the book. Chapters 11 and 12 present some easily applied formulas for determining the best curve for any arch, with illustrated examples of their use as an aid to the preliminary design. A chapter on the proportioning of reinforced concrete arches for the purpose of obtaining the greatest possible duty of reinforcement, contains some new and excellent methods of analysis. Calculating the stresses in an arch is the heading of the last chapter wherein the use of a chart for designing the reinforcement for single or double reinforced sections is illustrated. An appendix gives complete analytic and graphic computations for two notable European reinforced concrete arches. A list of references to European and American works on the subject closes the book.

The book contains so much materal not common to American works that it is certain to become one of the standard reference works on arches, and is without question deserving of a place in every engineer's library.

Fire Protection in Schools. The National Fire Protection Assn., Boston, paper, 8" x 11", 16 pp., illus.

This instructive publication points out the dangers of improper planning and construction in schools. It also contains a summary of the present state of school building regulations in the various states and gives a copy of the rules of the New York Board of Education. A limited number of copies are available for free distribution to those interested.

The importance of concrete and cement to the railroads is well illustrated in the important place given to the concrete section in the new laboraory that the Pennsylvania R. R. has just completed at Altoona, Pa. A large space is devoted to this field and every opportunity for testing cement and concrete in every possible way has been provided.

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[1] Foote Concrete Mchy. Co., Chicago

New Equipment, Methods and Materials:

New Tools with Which the Industry Works

This magazine will not publish "reading notices," so-called, for the benefit of advertisers. These pages are edited for the Reader, as are all other pages in "Concrete." Manufacturers are constantly producing new and better methods and developing old methods, materials and machines. The progress of the concrete field is measured by the development of its tools. All developments along these lines are of real interest and importance to men who want to improve the quality of their work, decrease its cost, increase its quantity. This department is for just that kind of Editorial material. We, therefore, welcome detailed announcements which will be of practical value to Readers. Under no circumstances will this magazine publish any announcement simply because an advertiser asks it, nor refuse publication because a non-advertiser asks it. Material must carry information of real consequence to the reader. All material will be edited on that basis regardless of the source from which it comes.—THE EDITORS.

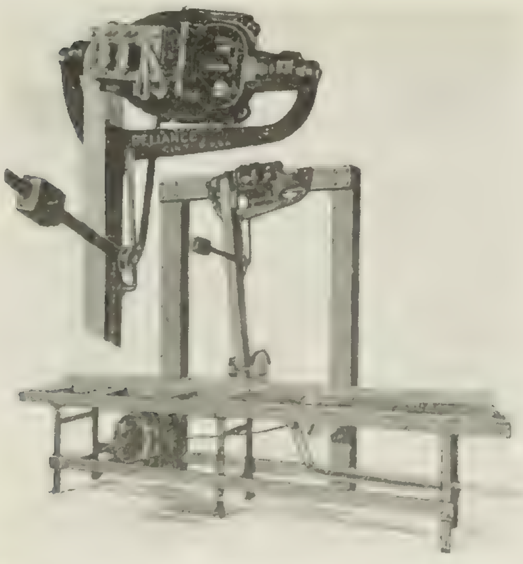

FIG. 1—THE RELIANCE COMBINATION CROSS CUT AND RIP SAW

An Adaptable Motor-Driven Saw Rig

The economy of a portable saw rig on the job, not only to cut up materials for concrete forms but also for the thousand and one jobs for which such an outfit can be utilized, has resulted in highly specialized equipment along this line. It has been demonstrated, however, that the swing saw possesses many advantages peculiar to itself. For instance, in cutting long and heavy lumber at an angle it is a simple matter to hold the timber to the angle desired and swing this saw across it.

The Reliance combination cross-cut and rip saw[1] has been developed to meet the needs of this class of work. The outfit as shown in the illustration consists of two motor-driven units, a rip saw that is used in connection with a table and a swing saw which can be either combined on the same saw-table, as shown in the illustration, or can be mounted wherever desired, according to the requirements of the job. For instance, on work requiring large panels which are to be ripped a wider table would be needed and it might be convenient to install the two machines entirely separately.

The upper part of the illustration shows in detail the mechanism of the swing saw, which consists of a motor, direct-connected to the driving pulley and amply protected by proper fuses. When the outfit is mounted as shown, safety is provided by means of a double throw switch which makes it impossible to start more than one saw at a time. The compact nature of the outfit and its ready adaptability to various requirements seem to recommend it strongly.

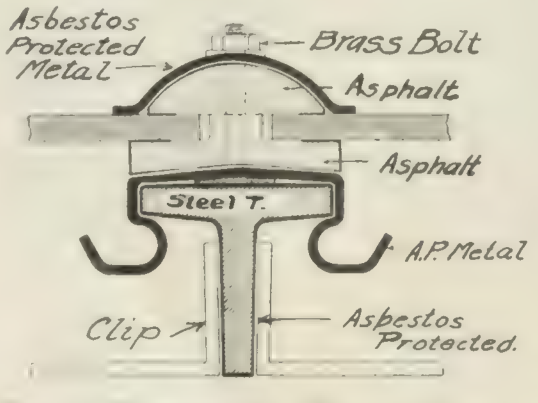

FIG. 1—SECTION OF WAUGH GLAZING CONSTRUCTION

A New Glazing Construction

For some time sheet metal has been successfully protected by an asbestos coating which in a large degree prevents rusting and destruction of the metal by gases and oxydization. The same construction is now being applied to metal skylight bars and an improved glazing system[1] has been worked out.

As will be seen by the sketch, steel T's are attached by clips to the purlins. Asbestos protected metal encloses the top member of the steel T's and in the case of skylights is formed into gutters to carry away condensation. A specially prepared strip of asphalt felt covers the metal and forms a bed for the glass. Another strips of felt covered with a special section of protected metal completes the glazing, which is secured by a brass bolt as shown in the illustration.

It is claimed that this construction accommodates itself readily to irregularities in the glass and secures permanently waterproof joints.

Denver, Col., claims the greatest number of "movie' houses of any city. One entire street is exclusively occupied by them. It is interesting to note that concrete is the only material allowed for their construction. Not only floors and walls but also balconies, boxes and even organ sounding-boxes are concrete.

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[1] Reno-Kaetker Electric Co., Cincinnati

[1] Asbestos Protected Metal Co., Pittsburgh

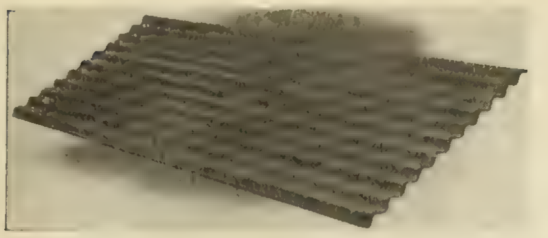


Fig. 1—Corrugated Asbestos Concrete Sheet

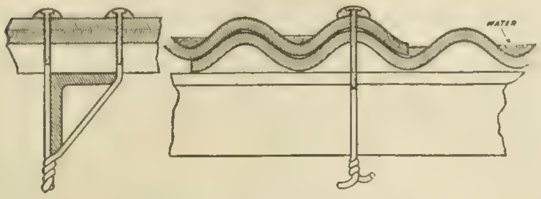


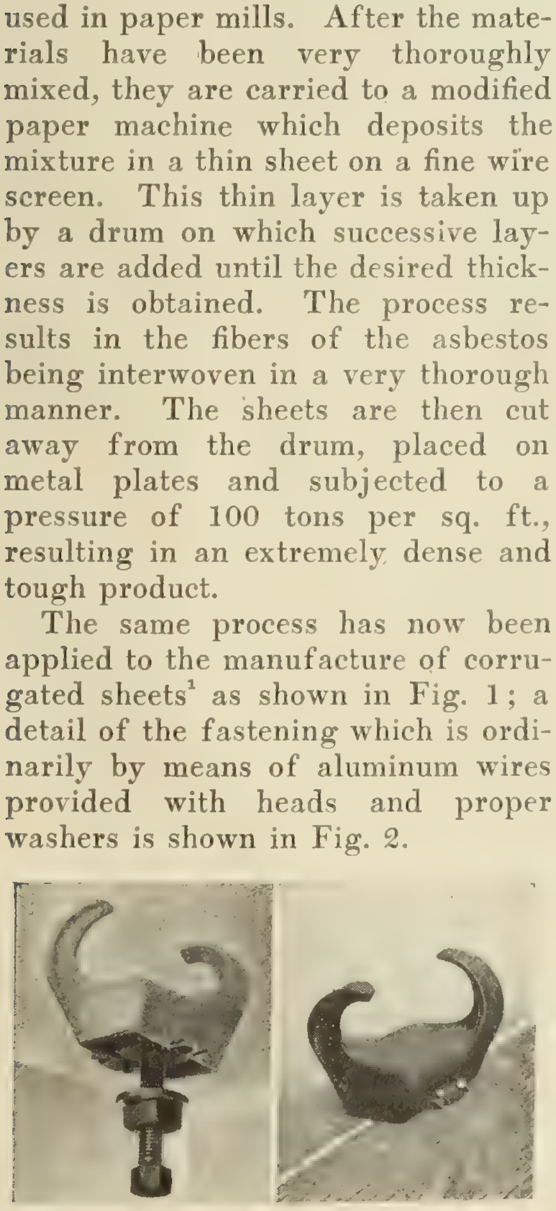
Fig. 2—Detail of Fastening

Corrugated Asbestos Roofing and Siding

The asbestos shingle has become a well known roofing material. It is generally understood that these shingles are made of Portland cement with asbestos as a binder. It is not, perhaps, so generally known how the materials are manufactured in the form of shingles.

Owing to the fibrous nature of the asbestos it is a difficult matter to mix it thoroughly with cement, as the numberless air cells in the asbestos prevent close union. The problem has been solved, however, by the use of a beating engine similar to those used in paper mills. After the materials have been very thoroughly mixed, they are carried to a modified paper machine which deposits the mixture in a thin sheet on a fine wire screen. This thin layer is taken up by a drum on which successive layers are added until the desired thickness is obtained. The process results in the fibers of the asbestos being interwoven in a very thorough manner. The sheets are then cut away from the drum, placed on metal plates and subjected to a pressure of 100 tons per sq. ft., resulting in an extremely dense and tough product.

The same process has now been applied to the manufacture of corrugated sheets[1] as shown in Fig. 1; a detail of the fastening which is ordinarily by means of aluminum wires provided with heads and proper washers is shown in Fig. 2.



The Donley Concrete Insert

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[1] Keasbey, Mattison & Co., Ambler, Pa.

An Adjustable Insert For Concrete Buildings

The fact has been well established that every concrete building for industrial purposes should be provided with means for quickly and economically attaching piping, machinery, etc. A large number of devices to accomplish this work have been brought out, one of the latest of which is called the D-B Concrete Insert.[1] It will be seen by the illustration this insert is merely placed on the forms and secured in position by tacks. The peculiar form of the anchorage allows a piece of steel reinforcing bar to be run through the insert, if desired, providing an unusually powerful anchorage. The anchor bolt is hung to a bridging washer, providing for a reasonable amount of adjustment.

A similar device is known as the D-B Foot Anchor. This is designed to be set flush with the top of a concrete floor and to provide the fastening for furniture, machinery, etc., with reasonable adjustment in all directions.

Floor Hardener Stands Test

The very active interest of builders in better concrete floors makes welcome any data developed through impartial tests.

Prof. R. R. Shively, Ph. D., of the Mellon Inst. of Industrial Research, has made such tests and reports as follows:

> A test floor was prepared, the base and the top being laid at the same time. The base was laid in the ordinary manner and while still green, the following finish coat was used: 1 part of cement, 2 parts of sand and 5 pounds of Resisto[2] to each bag of cement mixed thoroughly until an even color resulted; then sufficient water was added. It was laid and straight-edged to a true and even surface, employing wooden floats to close all voids. The facing was then applied; 20 lbs. of Resisto was sieved evenly over each 100 sq. ft. of surface. This was floated in and thoroughly troweled, a second troweling being given after the floor had set sufficiently to finish smooth and hard. The facing was not applied, however, until all surplus water had disappeared from the surface. When the floor had set so that it could not be scratched, it was covered with a layer of sawdust and kept wet for about 1 wk. The floor so obtained was of such a nature that it was suited for heavy work after about 3 wks.
>
> Samples of the test floor prepared as described above were compared with samples of unprepared concrete floors. It was found that while the tensile strength was practically the same the prepared sample possessed a harder surface and was more dense, the porosity being practically eliminated. When a sample of prepared concrete and a sample of untreated floor were rubbed together, the loss in weight of the latter amounted to approximately 10 times that of the treated sample. These tests on the loss of weight upon abrasion serve as a measure of toughness; the results show that the treated floor is much harder and less likely to dust.
>
> It was also shown that the treated floor does not absorb liquids so readily as the untreated concrete. Tests were also conducted in the laboratories which showed that rough finish sidewalks treated in the same way are superior to ordinary rough finish concrete walks.
>
> Tests conducted in the laboratories of the Institute with samples of test floors prepared according to other specifications gave similar results.

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[1] The Donley Bros. Co., Cleveland

[2] Pittsburgh Crushed Steel Co., Pittsburgh

Centrifugal Pump, Belt-Connected to Electric Motor

Centrifugal Pump for Contracting Operations

The last few years have seen the centrifugal pump developed to a very high degree of efficiency. Formerly, it was considered as a low head pump, but it is now operating efficiently against heads up to 125′. Some of the advantages of the centrifugal pump are that it is very small in size, easily installed and readily connected to any available source of power. Without damage these pumps will handle dirty or silty water or even water containing stones of considerable size. In case of accidental stoppage of the discharge pipe, the power consumption is increased but no serious damage will result to the pump as it will simply act as though pumping against increased head. This type of pump is now available in portable form in combination with gasoline engine or to be connected with any convenient source of power. The illustration shows the American[1] pump as installed for a temporary water supply. In the illustration the pump is being tested out, both the suction and the discharge pipe being plainly shown. Direct-conncted outfits to electric motors or other power are also made, which are efficient for permanent installation.

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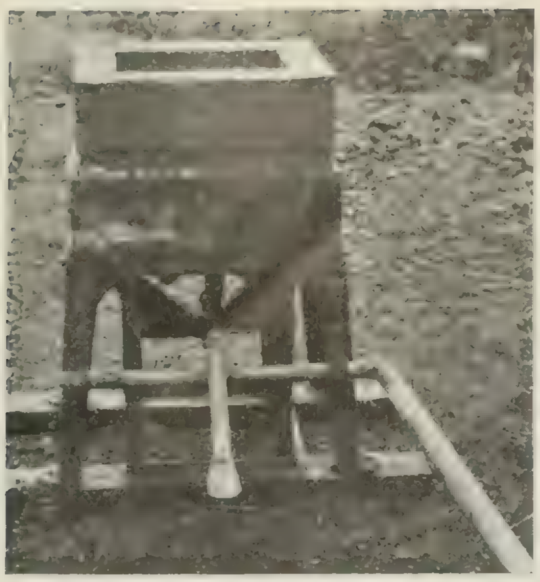
[1] American Well Works, Aurora, Ill.



New Chimney Block Machine

Chimney Block Machine

The accompanying illustration shows a simple machine[1] for making chimney blocks in two sizes, intended chiefly for use with vitrified crock lining. The pallet is placed in the machine, the concrete placed, rammed and smoothed at the top. By means of the levers, the block is then stripped upward out of the pallet. The machine is made to produce block with 3-in. walls to cover lining 8″ x 12″ and 8″ x 8″. The outside dimensions are 15″ x 19″ x 6¾″ high and 15″ x 15″ x 6¾″ respectively. In order to comply with building regulations in some cities, machines are being made to produce blocks with 4-in. walls.

Curb Bar

The new Universal curb bar[2] is shown in section in Fig. 1 and being installed in Fig. 2. Its design and use are so evident in the illustrations as to require no detailed description.

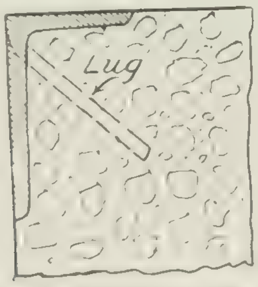


Fig. 1—Cross Sectional View of Corner, or Curb Bar

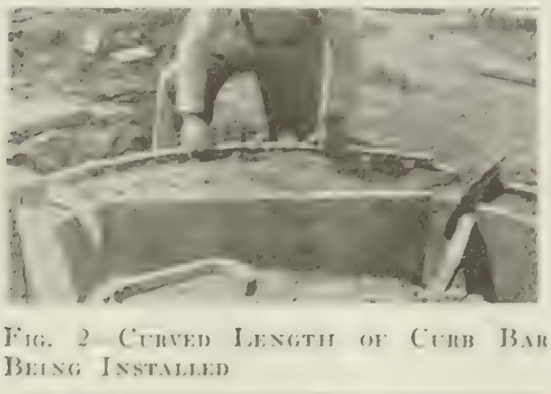


Fig. 2 Curved Length of Curb Bar Being Installed

Trade Publications

Announcing the removal of the W. E. Dunn Mfg. Co.—This is a very attractive 4x6 folder announcing that Nov. 1 the factories and general offices of the W. E. Dunn Mfg. Co., making a line of equipment already well known in the concrete field, were removed from Chicago, Ill., to Holland, Mich. The announcement contains the information that the new factory has five times the facilities of the old quarters. This is another step in 11 years of development.

Why Copper Alloy?—Clarence W. Noble, Toronto, Ont., paper, 6″ x 9″, 20 pp., pamphlet, illust. An exceptionally nicely printed and well presented paper as to why metal lath made from steel containing a certain percentage of copper is strongly resistant to corrosion, with special reference to gypsum plaster. Series of tests with halftones and diagram are included.

Santilite Composition Flooring and Instructions for Laying—Sanitary Composition Floor Corp., Syracuse, N. Y., paper, 8½″ x 11″, 8 pp., illust. Containing detailed directions for laying Santilite Composition Flooring.

Imperial Sanitary and Fireproof Flooring—Imperial Floor Co., Rochester, N. Y., folder, 3″ x 6″, 6 pp. This effective folder in two color gives reasons why Imperial flooring is satisfactory material to use and presents a large number of references to those who have used it successfully.

The Crosby Clipper—American Hoist & Derrick Co., St. Paul, paper, 4½″ x 5½″, 16 pp., illust. The house organ of the American Hoist & Derrick Co., showing the use of Crosby clips in electric railroad construction and containing considerable valuable information as to the proper way to apply clips to wire cable.

Service to Industry—Mellon Institute of Industrial Research, Univ. of Pittsburgh, Pittsburgh, Pa., paper, 6″ x 9″, 12 pp., illcst. An exceptionally attractive booklet, showing the scope of the Mellon Institute. This Institution specializes particularly on the solution of manufacturers' industrial problems and this booklet gives the reader a very clear idea of how such work is conducted.

Steel Forms and Centering for Plain or Reinforced Seamless Concrete Pipe—The Standardized Steel Form Co., Niagara Falls, N. Y., paper, 7″ x 10″, illust. Pamphlet describes a system of steel forms for constructing pipe and tunnel structures over 24″ in diameter. Several new and interesting features are shown in connection with this equipment.

"Hummer" Self-Rotating Hummer Drills—Chicago Pneumatic Tool Co., Chicago, paper, 6″ x 9″, 28 pp., illust. This is Bulletin No. 216 and describes in detail the "Hummer" drill, showing its construction by sectional drawings and also illustrations showing the drill in actual use. Lists of drills and accessories are included.

Concrete Silos—United States Portland Cement Co., Denver, Colo., folder, 3½″ x 6″, 6 pp., illust. This folder, which is printed on stiff bristol board so that it can be carried in the pocket for ready reference, gives much condensed information of value to the silo builder, including brief directions, worked out examples showing the method of figuring the materials needed, also a table giving the quantities of materials commonly used, sizes, tables of reinforcing and tables showing the proper size for various herds, together with silo cross-sections.

Union Steel Chain—The Union Chain & Mfg. Co., Seville, Ohio, paper, 6″ x 9″, 48 pp., illust. This publication describes a pressed steel chain of unique design and adapted to all types of chain transmission work. Various types and sizes are illustrated in great detail.

Saving Ways in Busy Shops—Hauck Mfg. Co., Brooklyn, N. Y., paper, 6″ x 9″, 16 pp., illust. Attractive catalog describing various types of kerosene torches and furnaces for heating operations in machine shops and on construction work.

Coal Gas Plant at the Fall River Gas Works Co.—Stone & Webster Engrg. Corp., Boston, paper, 7″ x 10½″, three colors, illust. This is an exceptionally finely printed booklet and describes a recent installation by this well known firm of engineers.

Modern Buildings—Trussed Concrete Steel Co., Youngstown, Ohio, paper, 8½″ x 11″, 32 pp., illust. House organ of the Trussed Concrete Steel Co., illustrating and describing modern concrete work with special reference to this company's products. A thoroughly interesting and well edited publication.

A Low-Charging Mixer—The T. L. Smith Co., Milwaukee, folder, 7″ x 10½″, 4 pp., illustr. This attractive folder describes the New Smith Mixerette, with low-charging features, in a convincing and interesting manner.

Waugh Glazing Construction—Asbestos Protected Metal Co., Pittsburgh, paper, 8″ x 10½″, 20 pp., illustrated. An unusually attractive booklet giving details of an improved method of skylight and steel sash glazing. The illustrations and the text clearly convey the merits of the construction to the reader and numerous samples of buildings where this glazing system has been used are given.

Bad concrete is worrying the County Controller of Montgomery Co., Pa. He stopped work upon a bridge because the work did not come up to specifications. Upon his personal visit to the job he found that only half the quantity of the cement required by the specifications was being used by the contractor and that the samples that he took from the job showed not a semblance of adhesiveness. Skimping of cement does not seem in this case to have been much economy to the contractor, and the Controller is right in his action in stopping the work, for in these days of floods and disasters, concrete for bridges and retaining walls cannot be skimped without endangering life and property.

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[1] Riley Smith, Springfield, Ohio

[2] Universal Concrete Bar Co., Chicago.

Novel Development in the Use of Gravity Concrete Mixer

The use of gravity for mixing concrete by allowing the aggregates and cement to run through a series of hoppers is by no means new. Gravity mixers have been largely employed on various types of work for some years. Comparatively recent, however, is the adaptation of this system to tower and spouting systems. The illustration shows the latest development in this direction[1] and will make the method of operation clear. It will be seen that the concrete materials are placed in the hopper at ground level, making charging an easy matter. A power-driven hoist quickly elevates the hopper to the position shown by the dotted line, the gate is opened and the batch runs quickly to the other mixing hoppers while the charging hopper returns for more material. This installation seems to be very practical and economical.

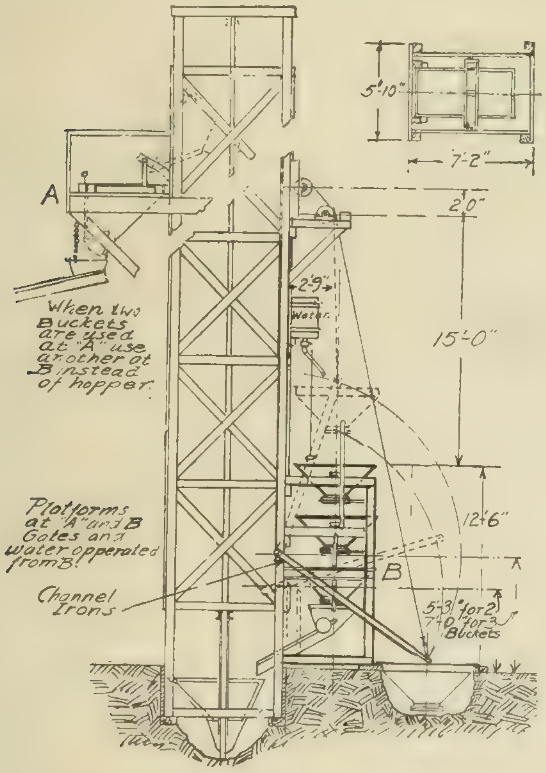
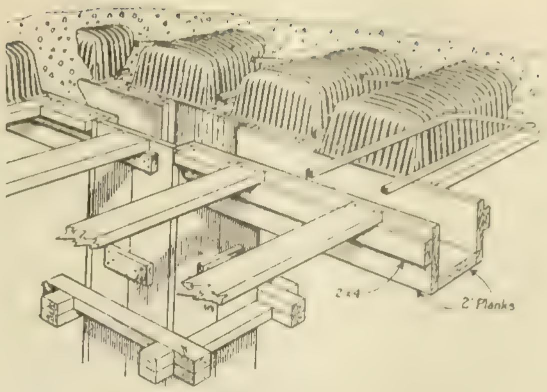

5'-10"
7'-2"
A
2'0"
2'-9"
Water
15'-0"
When two Buckets are used at "A" use another at B instead of hopper.
12'-6"
Platforms at "A" and B Gates and water opperated from B!
B
Channel Irons
5'-3" for 2
7'-0" for 3 Buckets

Diagram of Gravity Mixer in Connection with Spouting System

Non-Removable Sheet Steel Forms for Floor Construction

The past few years have seen placed upon the market a number of types of pressed sheet steel forms, designed to be used in connection with beam and slab floor construction. The theory in connection with this system is that a floor constructed of comparatively thin slabs and a large number of closely placed shallow beams is economical and extremely rigid. The use of the sheet steel forms eliminates a large amount of dead load which is inevitable in the case of hollow tile and beam construction.



Typical Steel-Tile Floor Arrangement

The latest form of this type, as shown in the illustration,[1] consists of a corrugated sheet steel plate, stamped to the required section as shown. Special plates for the end closures are provided. In the use of this type of form, 2-in. x 6-in. planks are placed at suitable intervals on bearing members and form the beam bottom. The illustration gives a good idea of the typical floor arrangement.

A Reinforced Concrete R. R. Tie

The concrete railroad tie seems to many inventors to offer a fruitful field for investigation. It is evident that the successful tie must be able to resist enormous bending stresses and the constant vibration due to the passage of heavy trains. The tie illustrated is the result of experiments during the past 11 yrs.[2] A number of forms of reinforcement and rail fasteners were tried out, both of which were found to have defects but which pointed the way toward a more successful application.

At Fig. 1 is shown a diagram illustrating the method of placing the reinforcing. It will be noticed that it gives a truss-like action at the points of maximum stress, namely, under the rail and at the middle of the tie. The standard tie is 7″ deep, 8″ wide and 8′ long and is reinforced by 10 trussed or bent rods placed as shown. Careful inspection will show that each rod is bent at one end and no rod runs straight through. Provision is made for a slight cushioning of the rail by casting slots in the flat top of the ties which take a thin wood shim. The rail fastening is provided by pipes which are cast in the tie and serve to secure the rail bolt. At Fig. 2 is shown a type of rail fastening which has proved its value. This consists of an L-shaped bolt used in connection with a cast iron clip and spring washer. The illustration shows two fasteners on the outside of the rail, this being the construction used on curves only. Fig. 2 also shows a detail of another type of fastener which is intended to prevent corrosion due to the drippings from refrigerator cars. This consists of an L-shaped bolt, a threaded sleeve and a machine bolt used in connection with the clip. This fastener allows plenty of adjustment for shimming and exposes no bolt thread to the weather. Fig. 2 also shows a number of ties in the casting yard which are now being tested out under service conditions.

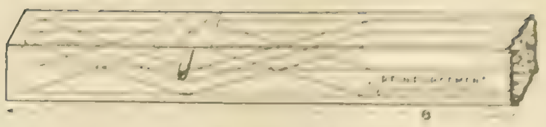


Fig. 1 Diagram of Reinforcing for Concrete Tie

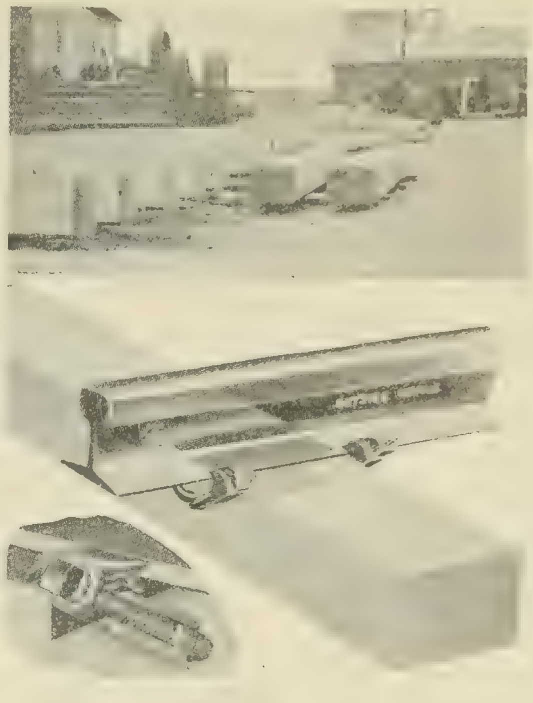


Fig. 2 Detail of Rail Fastening and Concrete Ties in Storage Yard

Some of the older types of ties were placed as long as seven years ago and are still doing service. While some small cracks have developed, none of the ties has had to be replaced. It is expected that the improved system of placing the reinforcement and more care in the concrete work will result in the present tests being entirely satisfactory.

The cost of the concrete ties under ordinary manufacturing conditions are about as follows: 10 5/16-in. twisted bars, 45 cts.; 1 sack of cement, 40 cts.; 3 cu. ft. of gravel, 5 cts.; labor, 15 cts.; total, $1.05. Under favorable conditions these costs would be reduced.

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[1] Automatic Concrete Mixer Co., Providence, R. I.

[1] General Fireproofing Co., Youngstown, Ohio

[2] Louis Blessing, Jackson, Mich.

Concrete Floors Improved by Surface Treatment

The problem of securing satisfactory concrete floors is one that is ever before architects and contractors. It is a demonstrated fact that well graded concrete materials, laid by expert workmen and carefully cured, will give satisfactory results. Many materials intended to be incorporated into the top coat to give greater wearing service have been tested. Some of these seem to be very successful.

It is an unfortunate truth, however, that many concrete floors now exist which for one reason and another are not entirely satisfactory. For such floors a surface treatment is essential. This is usually secured by treating the floor with some chemical solution which unites with the concrete, filling the pores and resulting in a more dense surface. A material called Lapidolith[1] has been extensively used, apparently with excellent results. This material is furnished in a condensed form which is diluted with water to the proper consistency. After cleaning the concrete floor thoroughly and allowing it to dry, it is necessary to give it from one coat to three coats to secure proper surface. This material is particularly recommended for concrete floors which are poorly laid and show excessive disintegration and dusting. Following are tests made on treated and untreated surfaces to moisture and abrasion.

ABRASION TEST BY BAUSCHINGER APPARATUS

Treated cubes, 2 wks. old, showed the following results after 200 revolutions of the abrasion disc:

Untreated sample weighed
before the test........750 grams
After the test...........429 "
Loss—————321 grams
Treated sample weighed
before the test........770 grams
After the test...........742 "
Loss————— 28 "

Difference in favor of treated
sample ....293 grams

PERMEABILITY TEST

Water was forced, under 30 lbs. pressure, through sections of pipe 1″ deep and 6″ in diam., filled with treated and with untreated concrete. The concrete used was composed of 1 part of Portland cement and 3 parts of 20-30 Ottawa sand. The figures below represent cu. cm. of water which permeated the bodies of concrete in given times:

Time	Treated	Untreated
1 min.	0.154	1.131
30 min.	0.073	0.185
60 min.	0.047	0.173

The Road Supervisors at Alhambra, Cal., have just passed resolutions instructing the Road Commrs. in the future to prepare all specifications for improved county roads, "providing for concrete construction, unless interested property owners specifically designate some other form." The resolution was carried unanimously, the evidence at the meeting showing, first, the superiority of concrete roads over other kinds of highway, and, second, that concrete construction for a term of years would be found cheaper than oil macadam if within $2,000 per mi. of the cost of the latter at the time of the initial expenditure.

Macon, Ga., is to have a public drinking fountain of concrete. The city engr. is designing a standard form to be used generally in that municipality. The fountain as planned will have a square base supporting a tapering column, both of concrete. The column will be ornamented by a malleable iron bowl and, exclusive of the iron bowl, the cost will be less than $10. The claims made for the fountain are attractive appearance, low cost and the delivery of cool water.

Announcement is made by the Automatic Sealing Vault Co., Peru, Ind., that it has taken over the business of the Indiana Concrete Mold Co., Peru, Ind., and will continue to manufacture the Indiana steel forms for concrete construction. This line includes sidewalks, curbs, curb and gutter, steps, posts, and other special forms of molds.

Current Prices — Concrete Materials

Portland Cement—A general increase in cement prices has taken place owing to the increased demand and the shortage of labor, which latter condition is causing the manufacturers some concern. Prices given are f.o.b cars at points named, including cloth sacks, for which, in general, 40 cts. per bbl. (5 sacks) is refunded on return in good condition. Prices per bbl. (including 4 cloth sacks) are as follows: Boston, $1.77; New York, $1.62; Chicago, $1.71; Pittsburgh, $1.71; Cleveland, $1.85; Detroit, $1.80; Indianapolis, $1.84; Toledo, $1.79 to $1.84; Milwaukee, $1.83 to $1.88; Minneapolis and St. Paul, $1.93 to $1.98; Duluth, $1.96; Peoria, $1.79; Cedar Rapids, $1.90; Davenport, $1.80; Toronto, $1.90; Montreal, $2.00; Winnipeg, $2.60; Vancouver, $2.75; Spokane, $2.35; Seattle, $2.40; Portland, Ore., $2.40; Tacoma, $2.40.

Crushed Stone—1½-in. stone, prices per cu. yd., f.o.b. cars in carload lots, unless otherwise specified. New York, 80 cts. to 90 cts., in full cargo lots at the docks; Chicago, $1.15; Winnipeg, $2.75; Vancouver, $1.50; Spokane, $1.00; Portland, Ore., $1.15; Seattle, $1.50.

Gravel—Prices given are per cu. yd. f.o.b. cars in carload lots unless otherwise noted. New York, 80 cts. in full cargo lots at docks; Chicago, $1.15; Winnipeg, $1.85; Vancouver, $1.25; Spokane, $1.00; Portland, Ore., 85 cts.; Seattle, 75 cts.; Tacoma, 75 cts.

Sand—Prices are per cu. yd. f. o. b. cars in carload lots unless otherwise indicated. New York, 45 cts., full cargo at docks; Chicago, $1.15; Winnipeg, $1.85; Vancouver, $1.00; Spokane, $1.00; Seattle, 75 cts.; Portland, Ore., 85 cts.; Tacoma, 75 cts.

Reinforcing Bars—The present Pittsburgh quotation on reinforcing bars is the highest since the formation of the Carnegie Co. and in addition the demand for large size bars for ammunition has made it practically impossible to obtain bars without long delays. To the contractor and builder this condition is by no means bright and some are asking, "Where will it all end?" At practically all points the bar companies are fighting off business and at Chicago the difficulty of obtaining steel bars is throwing some tonnage to the iron mills. At the present time practically all business is being taken on a basis of $1.70 per cwt., Pittsburgh, with prevailing extras for bars under ¾″ or base, and for delivery in 5 mos. to 7 mos., except in special cases. The following are quotations on base bars per 100 lbs., for mill shipments from other points, f. o. b. cars: New York, $1.869; Philadelphia, $1.859; Chicago, $1.882; Spokane, $2.60; Portland, Ore., $2.25; Seattle, $2.25; Tacoma, $2.25.

Shipments from stock are being made at the following prices per cwt. f. o. b. New York, $2.25; Buffalo, $2.20; Cincinnati, $2.25; Cleveland, $2.25; St. Louis, $2.15; Chicago, $2.10; St. Paul, $2.20; Toronto, $2.50; Winnipeg, $2.45; Vancouver, $2.90; Spokane, $2.80; Portland, Ore., $2.50; Tacoma, $2.50; Seattle, $2.50.

Metal Clips for Supporting Bars—$4.50 to $6.50 per 1,000, depending on size.

For the majority of the prices given we are indebted to the Universal Portland Cement Co., Concrete Steel Co., Sandusky Portland Cement Co., American Sand & Gravel Co., Chicago, and F. T. Crowe & Co., Seattle, Portland, Spokane and Tacoma.

Reinforcing bars for mill shipments are in general sold on a Pittsburgh basis: that is, at the Pittsburgh quotation plus the freight to the point in question, and with the following list of freight rates on finished material and the Pittsburgh quotation given, the price of bars at any of the points listed can be readily computed.

From Pittsburgh, carloads, per 100 lbs. to:

Albany	16.9	cts.
New York	16.9	"
Philadelphia	15.9	"
Baltimore	15.4	"
Boston	18.9	"
Buffalo	11.6.	"
Cleveland	10.5	"
Birmingham	45	"
Cincinnati	15.8	"
Chicago	18.9	"
Denver	68 6	"
St. Louis	23.6	"
New Orleans	30	"
Minneapolis	32.9	"
Indianapolis	17.9	"
Kansas City	43.6	"
Omaha	43.6	"
Pacific Coast Points (Rail)	73.9	"

Now that the Panama Canal has been opene to traffic ocean freight rates on reinforcing bars to Pacific Coast points have been established which materially lower the delivered cost of bars from the east. The rates per 100 lbs. to Pacific Coast points for large lots are. From Pittsburgh, 61.9 cts.; Chicago, 76.5 cts.; Youngstown, 61.9 cts.; New York, 40 cts.; Bethlehem, 52.9 cts.

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[1] L. Sonneborn Sons, Inc., N. Y. C.

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ENGINEERING

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